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REPORT ON

RESOURCE AND POTENTIAL RECLAMATION
EVALUATION
OF

CHROMO/4 STUDY SITE
OTTER CREEK COALFIELD
MONTANA
1978

.D STATES · DEPARTMENT OF THE INTERIOR · BUREAU OF LAND MANAGEMENT

AND
BUREAU OF RECLAMATION

RESOURCE AND POTENTIAL RECLAMATION EVALUATION

OF

CHROMO/4 STUDY SITE

OTTER CREEK COALFIELD, MONTANA

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RESOURCE AND POTENTIAL RECLAMATION EVALUATION OF CHROMO/4 STUDY SITE OTTER CREEK COALFIELD, MONTANA

INTRODUCTION

The nations ever increasing need for energy has focused attention on the abundant low sulphur coal resources in the Western States, primarily the Rocky Mountain and the Northern Great Plains regions, due to the abundance, ease of extraction, and the quality of the coal present. It is the responsibility of the Bureau of Land Management to assist in meeting the nation's energy demands and, at the same time, provide for reclaiming surface mined lands.

Purpose

This study will provide data for developing reclamation objectives at a potential coal leasing area. The site was selected to determine if existing data collected for the nearby Otter Creek Study Site (EMRIA No. 1) could be correlated or projected throughout the Otter Creek Coalfield.

Authority

This report is prepared in accordance with Section 4 of the Agreement between the Bureau of Land Management and the Bureau of Reclamation dated May 7, 1974.

Location

The Chromo/4 Site is located in Powder River County, about 12 miles (19.4 km) southeast of Ashland, Montana. The site includes all of Section 4, T. 5 S., R. 45 E. It is 1.5 miles (2.4 km) southwest of the Otter Creek East Study Site which was completed in 1976. Plate 1 shows the general location of all study sites in the Otter Creek Coalfield.

The Federal Government owns all coal deposits in the site. The surface is privately owned.

CLIMATE

The Chromo/4 Study Site is in the Otter Creek geographical area which has a continental-type climate. It is cold in the winter, warm in the summer and large daily variations are common. Elevation at the site ranges from 3155 (961) to 3400 ft. (1036 m). The Broadus weather station at elevation 3030 ft. (924 m) receive an average of 14.2 inches (361 mm) of precipitation annually and Birney, at elevation 3190 ft. (973 m) receives an average of 13.7 in. (348 mm) annually. Torrential rainstorms are common and unprotected soil surfaces may erode severely during these storms. These storms, though common, may not cover large areas. Hailstorms occasionally cross the area, but these weather extremes do not place the area in any particular type storm belt. About 53 percent of the precipitation falls as rain during the growing season. Growth of native range is rapid during May and June which are the wettest months of the year. Precipitation data from the Otter weather station 27 miles (43.5 km) southwest of this site follow:

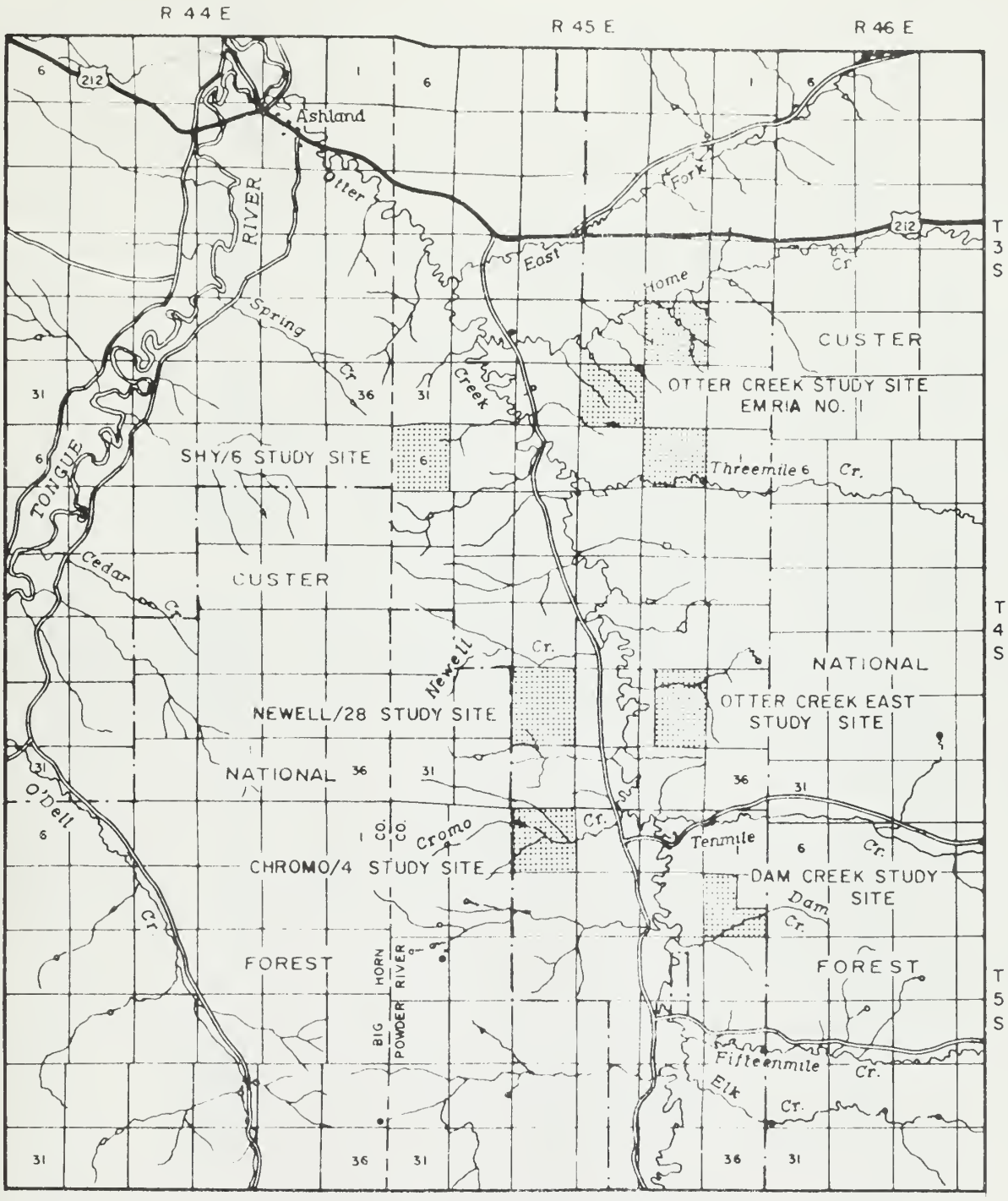
May	June	July	August	Sept.	Percent of Annual	Annual	
2.51	3.30	1.32	1.26	1.69	53	19.10 1/	inches
63.8	83.8	33.5	32.0	42.9	53	485.1	millimeters

The elevation of the Otter station is 4000 ft. (1219 m).

The frost-free period (32°F or 0°C) ranges from 108 days at Birney to 120 days at Broadus. The growing season for hardy grasses (28°F or -2.2°C) in average years begins May 10 at Birney and ends 131 days later on September 19. Following the spring rains, July is hot, dry and windy with excessive evaporation and evapotranspiration rates. Humidity is low. During the months of June, July and August, about 32 days have a temperature of 74°F (23.3°C) or higher. Average monthly temperatures exceed 51°F (10.6°C) in May, June, July, August, September and October. July with an average temperature of 74°F (23.3°C), is the hottest month and May and October with 51°F (10.6°C) are the coolest growing season months.

The climate in the Otter Creek area in most years is suited for reclamation of surface-mined land because the spring rains are generally adequate for establishing stands of native vegetation. The 13.7 (348) to 14.2 in. (361 mm) of precipitation received in average years meet the requirement of range vegetation which grows rapidly in the late spring and early summer. This moisture from natural precipitation is usually depleted by established native grasses in 6 to 8 weeks and the plants mature and become dormant. Consumptive use data in Table 1 show native grasses could use 22.5 inches (572 mm) of moisture if

1/ The Otter station is several hundred feet higher than this study site. The apparent effect is an increase in the precipitation especially during the nongrowing season.



GENERAL LOCATION MAP
FOR
OTTER CREEK COALFIELD
STUDY SITES

Multiply miles by 1 6093 to obtain kilometers

Table 1 - Potential Consumptive Use of Moisture and Available Moisture - Native Grasses [1/]

Chromo/4 Study Site

Month	Midpoint	Accumulative Days to Midpoint	Air Temp. (°C)	Monthly Requirement Millimeters	Moisture Reserve Millimeters[2/]	Precipitation Millimeters	Difference Millimeters[3/]
May 4					+ 102.6		
	May 17	13	12.6	71.1		56.6	+ 88.1
June					+ 85.6		
	June 15	42	17.3	120.6		79.5	+ 47.0
July					+ 47.0		
	July 15	72	21.8	161.5		34.5	- 80.0[4/]
August					- 80.0		
	August 15	103	21.0	140.2		27.4	- 192.8
Sept.					- 192.8		
	Sept. 13	131	14.6	77.5		30.5	- 239.8
Sept. 27		145					
				570.9		228.5	

1/ Computed by Blaney-Criddle Method using the Broadus Weather Station - Latitude 45°26' N.
2/ Moisture Reserve = Summation of precipitation (Oct. to April) = 128.3 x 0.80 = 102.6 millimeters
3/ Difference = Moisture Reserve plus precipitation minus moisture use
4/ Natural precipitation during most years is inadequate to meet potential moisture needs. In average years, the plants use the available moisture by July 15 and mature and become dormant.

available; but it also shows that 13.9 inches (353 mm), or the average annual precipitation could be used by July 15. Table 1 prepared for the Otter Creek Study Site also represents the potential comsumptive use in this site.

Reclamation of surface-mined land is very difficult in areas that consistently receive 10 in. (254 mm) or less of precipitation each year. In this area, years that receive less than the average annual precipitation are not common. The Broadus station reported less than 10 in. (254 mm) only three times in the last 37 years and Birney only once in the last 21 years.

PHYSIOGRAPHY

The Chromo/4 Study Site is in the unglaciated portion of the Great Plains physiographic province. Relief in the area ranges from 3755 ft. (961 m) on Chromo Creek in the eastern part of the area to over 3400 ft. (1036 m) in the southwestern part of the section. Topography varies from flat to gentle slopes along parts of the Chromo Creek Valley floor to a steep semi-badland type at the higher elevations where erosion of the underlying soft shale and weakly cemented sandstone has been severe. Drainages in the area have developed along a dendritic pattern leading into Chromo Creek which trends easterly to Otter Creek, a tributary of the Tongue River. Photographs 1 through 3 show the typical terrain in the study site.

Photograph 1 - Chromo/4 Study Site - Otter Creek Coalfield, Montana. Panoramic view looking west into the study site. Photograph was taken from trail in eastern part of Section 4.
U. S. Bureau of Reclamation photograph 11/16/77

Photograph 2 - Chromo/4 Study Site - Otter Creek Coalfield, Montana.
View of sandstone capped butte in southwest quarter of Section 4, T. 5 S., R. 45 E. Odell (?) clinker crops out about halfway up scarp.
U. S. Bureau of Reclamation photograph 11/16/77

Photograph 3 - Chromo/4 Study Site - Otter Creek Coalfield, Montana.
View looking downstream into the ravine in the northeast quarter of Section 4, T. 5 S., R. 45 E. Photograph taken from Drill Hole 77-101.
U. S. Bureau of Reclamation photograph 11/16/77

GEOLOGY

Regional Geology

The Chromo/4 Study Site is located in the northern part of the Powder River Basin in southeastern Montana. This basin, a part of the unglaciated portion of the Great Plains physiographic province, is about 225 miles(362 km) long, extending from the Yellowstone River in Montana to the North Platte River in Wyoming. It is about 90 miles(145 km) in width, bounded on the west by the Bighorn Mountains and on the east by the Black Hills. Structurally, the basin is an asymmetrical syncline with a northwestward trending axis. An estimated 18,000 feet(5486 m) of sediments overlie the basement complex in the deepest part of the basin north of Glenrock, Wyoming.

The geologic history of the area since Precambrian time includes periods of deposition, deformation, and erosion. During the Paleozoic and Mesozoic Eras, a sequence of carbonates, sandstones, and shales was deposited throughout Montana and Wyoming. Thickness of these sediments on the west side of the basin varies from 9,000 feet(2743 m) near Yellowtail Dam to 11,500 feet(3505 m) near Buffalo, Wyoming. About 6,500 feet(1981 m) of Paleozoic and Mesozoic sediments are present in the Black Hills area on the east side of the basin.

The area was relatively stable during these periods with deposition usually occurring in a marine enviroment. Deformation of strata began with the Laramide Revolution near the close of the Mesozoic Era (Late Cretaceous), at which time mountain masses such as the Bighorns and Black Hills were uplifted. Uplift continued throughout Paleocene and gradually ended in Eocene time. Materials stripped from the mountains were deposited in fans or sheets across the basin floors, gradually burying the flanks of the mountains in their own debris. By the middle of the Cenozoic Era, the basins were largely filled and the mountains peneplained. In Pliocene time, a broad regional uplift occurred and continued intermittently into Pleistocene time. This uplift raised the previously developed peneplain surface to elevations of about 10,000 feet (3048 m) in the Bighorn Mountains. Streams rejuvenated by the uplift excavated the basins and exhumed the buried mountain masses.

Today, Precambrian rocks are exposed in the cores of the Black Hills and Bighorn Mountains. These rocks are surrounded by sediments of Paleozoic and Mesozoic Age. The central part of the basin is filled with Cenozoic (Tertiary) sediments.

Site Geology

Investigations

Previous geologic investigations have been conducted in the general area by the U. S. Geological Survey and the Montana Bureau of Mines and Geology. A list of relevant maps and publications follows:

1. U.S.G.S. Bulletin 1072-J - Reconnaissance Geology of the Birney-Broadus Coal Field, Rosebud and Powder River Counties, Montana.

2. U.S.G.S. Miscellaneous Field Studies Map MF-802 - Willow Crossing Quadrangle, Montana.

3. U.S.G.S. Miscellaneous Field Studies Map MF-807 - Fort Howes Quadrangle, Montana.

4. U.S.G.S. Miscellaneous Field Studies Map MF-814 - Browns Mountain Quadrangle, Montana.

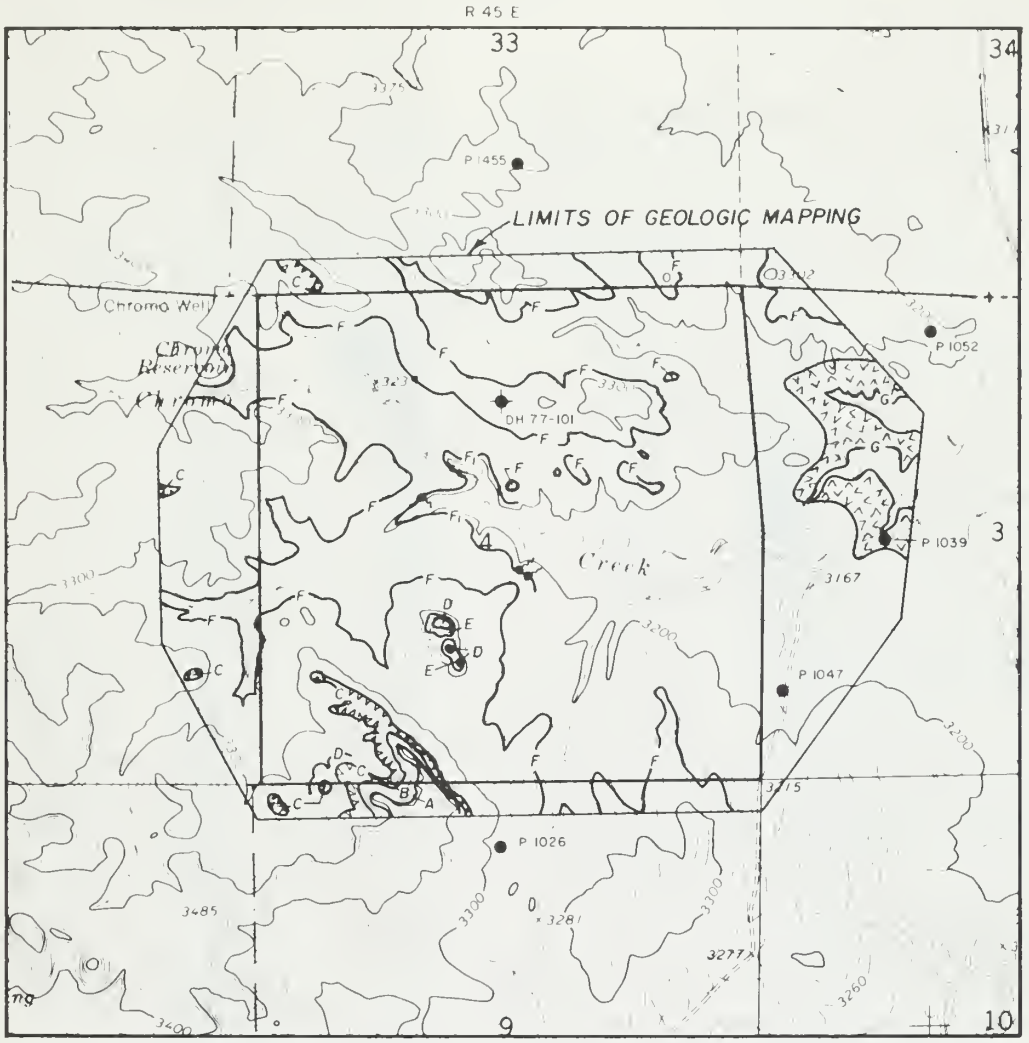
5. U.S.G.S. Miscellaneous Field Studies Map MF-817 - King Mountain Quadrangle, Montana.

6. Montana Bureau of Mines and Geology Bulletin 69 - Strippable Coal Deposits on State Land Powder River County, Montana.

7. Montana Bureau of Mines and Geology Bulletin 91 - Quality and Reserves of Strippable Coal, Selected Deposits, Southeastern Montana.

Geologic investigations were conducted at the Chromo/4 Study Site by the U. S. Bureau of Reclamation during November and December of 1977. Investigations included mapping the surface geology and drilling one core hole. Drill cores were tested by the U.S.B.R. Soils Laboratory for suitability in reconstructed profiles. Results of the tests are graphically shown on the geologic log. Detailed geologic mapping was done in the field on aerial photographs. The data were transferred to a topographic map and are shown on Plate 2. A detailed geologic log for Drill Hole 77-101 is included in this report (Plate 3).

Core drilling was performed using a Failing Model 314 rotary drill rig with an "H" series wire line core barrel. Water from Otter Creek was used as the drilling fluid. Test results conducted by the U.S.B.R. Soils Laboratory in Miles City, Montana, indicated that the total dissolved solids in the water supply was about 1900 parts per million (1900 mg/l).



EXPLANATION

PALEOCENE

FT UNION FORMATION (TONGUE RIVER MEMBER) – Interbedded shale, siltstone, sandstone and coal

CLINKER – Baked shale, siltstone and sandstone of the Fort Union Formation produced by burning of the Knoblock coalbed Up to 30 feet thick

Coalbed burned at outcrop

A through G – Coal and/or carbonaceous shale beds

A – 2 to 3 ft of coal and carbonaceous shale

B – 2 to 4 ft of coal

C – Coalbed burned at outcrop Probably over 5 feet thick Correspondes to Odell bed in U S G S bulletin 1072 J and Cache bed in U S G S Miscellaneous Field Studies Map MF-817

D – 2 to 4 ft of carbonaceous shale

E – 2 feet of carbonaceous shale

F – 2 to 4 ft of coal Probably corresponds to "A" and "C" beds in Otter Creek Study Site (EMRIA # 1) and to bed "F" in Otter Creek East and Dam Creek Study Sites

F_1 – 3 ft + of carbonaceous shale Minor water seeps occur along this bed at locations marked by ● symbol

G – Base of Middle Bench of Knoblock Coalbed

DH 77-101 USBR Drill hole

P 1455 Drill hole from USGS Miscellaneous Field Studies Map MF-817

1000 0 1000 2000 3000

SCALE OF FEET

NOTE

Multiply feet by 0.3048 to obtain meters

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

RESOURCE & POTENTIAL RECLAMATION EVALUATION

CHROMO/4 STUDY SITE
OTTER CREEK COALFIELD – MONTANA

GEOLOGIC AND INVESTIGATIONS MAP

GEOLOGY G. TAUCHER SUBMITTED

DRAWN L. E. ALLSOP RECOMMENDED

CHECKED APPROVED

BILLINGS, MONTANA APRIL 1978

1305-600-146

GEOLOGIC LOG OF DRILL HOLE — SHEET 1 OF 3

FEATURE: Chromo/4 Study Area, Otter Creek Coalfield
PROJECT: Work Order 005
STATE: Montana
HOLE NO: 77-101
LOCATION: 1200' S. & 2550' E. of NW Corner, Sec. 4, T. 5 S., R. 45 E.
GROUND ELEV: 3285±
DIP (ANGLE FROM HORIZ.): Vertical
BEGUN: 11-15-77
FINISHED: 12-2-77
DEPTH OF OVERBURDEN: --
TOTAL DEPTH: 232.1'
BEARING: --
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: 58.0' (3227'±) 12-2-77
LOGGED BY: Parish
LOG REVIEWED BY: --

Columns: NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING AND OTHER DRILLING CONDITIONS | TYPE AND SIZE OF HOLE | CORE RECOVERY (%) | SOILS ANALYSIS SAMPLE DEPTH (FEET) FROM / TO | SUITABILITY FOR RECONSTRUCTED PROFILE: SUITABLE / LIMITED SUITABILITY / UNSUITABLE | ELEVATION (FEET) | DEPTH (FEET) | GRAPHIC LOG | SAMPLES FOR TESTING | CLASSIFICATION AND PHYSICAL CONDITION

Notes on drilling conditions

Drill
Failing 314 truck-mounted.

Drillers
George Shaw
Gerald Becker

Method
Bx casing drive sample 0-1.5'. Rock bit wash samples 1.5-11.0'. Hq wireline core 11.0 to 232.1'. Reamed hole 0 to 40.5' with 6½" rock bit to set 5" casing. Water and revert used as drill fluid. Lost 25% of water 23 to 35'. 100% water loss 35-134.5'. 90% loss 134.5 to 204.5'. 100% loss 204.5-213.1'. 90% loss 213.1-232.1'.

Casing Record
Set 5" casing to 40.5' 11-16-77 to try to prevent water loss. Casing was pulled on completion of hole.

Progress Record

Depth	Date
0-55'	11-15-77
55-68.2'	11-16-77
68.2-94.5'	11-17-77

Snow conditions in the area prevented further drilling until 11-29-77.

94.5-134.5'	11-29-77
134.5-136.5'	11-30-77
136.5-213.1'	12-1-77
213.1-232.1'	12-2-77

Hole Completion
Casing pulled and hole backfilled 12-2-77.

Core recovery (%): 100, wash, 93, 87, 97, 100, 100, 95, 100, 71, 100, 89, 98, 90

Soils analysis samples

Sample	From	To
#1	0	22 (Except 1.5-11)
#2	24.7	35
#3	35	47
#4	47	64
#5	64	78.5
#6	78.5	100

Elevation / Depth

Elevation	Depth
3284.3	0.7
3270.4	14.6
3263.0	22.0
3260.3	24.7
3259.6	25.4
3250.0	35.0
3238.0	47.0
3233.0	52.0
3221.0	64.0
3216.3	68.7
3206.5	78.5

F

Classification and physical condition

FORT UNION FORMATION - PALEOCENE

0-0.7' TOPSOIL (WEATHERED SANDSTONE): About 85% fine sand; 15% nonplastic fines; strong HCl reaction; moist; crumbly to loose; scattered grass roots; tan to light brown (SM).

0.7-14.6' SANDSTONE: Gray with rusty streaks; moist; uncemented; soft; crumbles easily; fine to medium grained; slightly laminated; bedding nearly horizontal; no HCl reaction; core lengths to 10".
NOTE: 1.5-11.0' logged from wash samples.

14.6-22.0' SHALE: Gray with rusty streaks and bands; moist; firm; trims easily with knife; plastic; air slakes; bedding nearly horizontal; very weak HCl reaction; core lengths to 18".
14.6-14.8' - Rusty, weathered concretion.
19.5-20.3' - Joint dipping 80°
21.0-22.0' - Carbonaceous zone; core crushed and slickensided.

22.0-24.7' COAL: Black; damp; hard; brittle; badly broken; core lengths to 3".

24.7-25.4' SANDSTONE: Light gray; damp; uncemented; crumbles with difficulty; fine grained; contains some silt; no HCl reaction; bedding not discernible; core lengths to 4".

25.4-35.0' SHALE: Light gray with rusty streaks varying to nearly black in one zone; damp; firm; difficult to cut with knife; bedding nearly horizontal; weak to strong HCl reaction; core lengths to 2'.
25.4-26.4' - Sandy, laminated.
26.4-28.0' - Carbonaceous; black; plastic; air slakes; coal streaks 27.7 to 28.0'.
33.7-34.0' - Sandy; laminated; tan colored bands of fine sand.

35.0-47.0' SANDSTONE: Light to medium gray with a few rusty streaks 35.0 to 38.0'; damp; uncemented; firm; some zones crumble easily, but others are difficult to crumble; fine grained; scattered laminated zones; bedding nearly horizontal; weak to strong HCl reaction; core lengths to 2'.
35.0-37.0' - Scattered thin carbonaceous layers.

EXPLANATION

CORE LOSS / CORE RECOVERY

Type of hole: D = Diamond, H = Hoystellite, S = Shot, C = Churn
Hole sealed: P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X series): Ex = 1-1 2", Ax = 1-7 8", Bx = 2-3 8", Nx = 3"
Approx. size of core (X series): Ex = 7 8", Ax = 1-1 8", Bx = 1-5 8", Nx = 2-1 8"
Outside dia. of casing (X series): Ex = 1-13 16", Ax = 2-1 4", Bx = 2-7 8", Nx = 3-1 2"
Inside dia. of casing (X series): Ex = 1-1 2", Ax = 1-29 32", Bx = 2-3 8", Nx = 3"

FEATURE Chromo/4 Study Area, Otter Creek Coalfield PROJECT Work Order 005 STATE Montana SHEET 1 OF 3 HOLE NO 77-101

GEOLOGIC LOG OF DRILL HOLE — SHEET 2 OF 3

FEATURE: Chromo/4 Study Area, Otter Creek Coalfield
PROJECT: Work Order 005
STATE: Montana
HOLE NO: 77-101
LOCATION: 1200' S. & 2550' E. of NW Corner, Sec. 4, T. 5 S., R. 45 E.
GROUND ELEV: 3285±
DIP (ANGLE FROM HORIZ.): Vertical
BEGUN: 11-15-77
FINISHED: 12-2-77
DEPTH OF OVERBURDEN: --
TOTAL DEPTH: 232.1'
BEARING: --
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: 58.0' (3227'±) 12-2-77
LOGGED BY: Parish
LOG REVIEWED BY: --

Water Levels
All were taken before hole was completed.

Depth	Date
40'	11-16-77
47.5'	11-17-77
51'	11-18-77
57.2'	11-29-77
57.2'	11-30-77
58'	12-1-77
58'	12-2-77

Core recovery (%): 100, 100, 100, 100, 100, 100, 100, 100, 100, 100, 100

Soils analysis samples

Sample	From	To
#7	100	115
#8	115	143.9
#9	149.7	154.5

Elevation / Depth

Elevation	Depth
3170.0	115
3141.1	143.9
3135.3	149.7
3130.5	154.5
3104.2	180.8
3103.0	182
3096.1	188.9
3094.1	190.9
3092.8	192.2

G

Classification and physical condition

42.0-43.5' - Hard; light gray; cemented; calcareous.

47.0-52.0' SANDY SHALE: Gray; damp; firm; difficult to cut with knife; laminated; bedding nearly horizontal; strong HCl reaction; core lengths to 15".

52.0-64.0' SHALE: Light to dark gray; damp; firm; will barely trim with knife; laminated; contains some plastic zones that air slake; bedding nearly horizontal; weak to strong HCl reaction; core lengths to 1'.
54.5-59.5' - Carbonaceous; dark gray; plastic; air slakes.
61.0' - Joint dipping 70°.
62.0' - Joint dipping 60°.
63.0-64.0' - Silty; hard; light gray; calcareous.

64.0-68.7' SANDSTONE: Light to medium gray; dry to damp; uncemented; crumbles with some difficulty; fine to medium grained; bedding not discernible; weak HCl reaction; core lengths to 15".
67.0-68.7' - Light gray; cemented; hard; calcareous.

68.7-78.5' SHALE: Light to medium gray; damp; firm; will barely trim with knife; laminated; sandy near top; bedding nearly horizontal; strong HCl reaction; core lengths to 1'.

78.5-115.0' CARBONACEOUS SHALE: Dark gray to almost black; damp; firm; will barely trim with knife; plastic; air slakes; bedding nearly horizontal; no HCl reaction; core lengths to 2'.
82.5' - Joint dipping 70°.
85.0' - Joint dipping 40°.
88.5-89.0' - Sandstone; light gray; fine grained; laminated.
89.5-90.0' - Sandstone; light gray, silty.
93.0' - Joint dipping 70°.
102.8' - Joint dipping 60°.

115.0-143.9' SANDY, SILTY SHALE: Highly variable; light gray; damp; firm; barely cuts with knife; laminated with thin sand and silt layers; bedding nearly horizontal; strong HCl reaction; core lengths to 2'.
118.0' - Slickensides dipping 45°.
122.2-123.3' - Carbonaceous; air slakes.
143.6-143.9' - Carbonaceous; air slakes.

143.9-149.7' COAL: Black; hard; brittle; broken.

149.7-154.5' SHALE: Light gray; damp; firm; barely trims with knife; laminated;

EXPLANATION

CORE LOSS / CORE RECOVERY

Type of hole: D = Diamond, H = Hoystellite, S = Shot, C = Churn
Hole sealed: P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X series): Ex = 1-1 2", Ax = 1-7 8", Bx = 2-3 8", Nx = 3"
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FEATURE Chromo/4 Study Area, Otter Creek Coalfield PROJECT Work Order 005 STATE Montana SHEET 2 OF 3 HOLE NO 77-101

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FINISHED: 12-2-77
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TOTAL DEPTH: 232.1'
BEARING: --
DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED: 58.0' (3227'±) 12-2-77
LOGGED BY: Parish
LOG REVIEWED BY: --

Core recovery (%): 100, 93, 100, 100

Soils analysis samples

Sample	From	To
#10	192.2	215.3
#11	225.6	232.1

Elevation / Depth

Elevation	Depth
3077.0	208
3069.7	215.3
3059.4	225.6
3052.9	232.1

Classification and physical condition

air slakes; core feels silty but has a shiny, plastic type knife cut; contains numerous carbon film plant fossils and thin coal streaks; bedding nearly horizontal, no HCl reaction; core lengths to 10".
150.1-150.9' - Coal lense.

154.5-180.8' COAL: Black; hard; brittle; broken.

180.8-182.0' SHALE: Medium gray; damp; firm; barely trims with knife; contains scattered carbon film plant fossils; air slakes; bedding nearly horizontal; numerous slickensides 180.8 to 181.0'; core lengths to 6".

182.0-188.9' COAL: Black; hard; brittle; broken.

188.9-190.9' SILTSTONE: Light gray; damp; firm; cuts fairly easily with knife; scattered coal streaks; bedding not readily discernible but coal streaks are nearly horizontal; no HCl reaction; core lengths to 1'.

190.9-192.2' COAL: Black; hard; brittle; broken.

192.2-208.0' SILTY SANDSTONE: Light gray; damp; varies from uncemented, soft and crumbly to cemented, hard and calcareous; some zones are quite silty; laminated; strong HCl reaction; bedding nearly horizontal; core lengths to 18".
192.2-194.5' - Contains numerous carbon film plant fossils.

208.0-215.3' SANDY SHALE: Light gray; damp; firm; barely trims with knife; laminated; numerous thin sand lenses; air slakes; bedding nearly horizontal; weak HCl reaction; core lengths to 8".
215.0-215.3' - Carbonaceous.

215.3-225.6' COAL: Black; hard; brittle; not broken as much as usual.

225.6-232.1' SANDY SILTSTONE: Light gray; damp; firm; barely trims with knife; bedding not discernible; no HCl reaction; core lengths to 3'.
225.6-226.6' - Carbonaceous; shaley.
226.9' - Slickensides dipping 45°.

EXPLANATION

CORE LOSS / CORE RECOVERY

Type of hole: D = Diamond, H = Hoystellite, S = Shot, C = Churn
Hole sealed: P = Packer, Cm = Cemented, Cs = Bottom of casing
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Approx. size of core (X series): Ex = 7 8", Ax = 1-1 8", Bx = 1-5 8", Nx = 2-1 8"
Outside dia. of casing (X series): Ex = 1-13 16", Ax = 2-1 4", Bx = 2-7 8", Nx = 3-1 2"
Inside dia. of casing (X series): Ex = 1-1 2", Ax = 1-29 32", Bx = 2-3 8", Nx = 3"

FEATURE Chromo/4 Study Area, Otter Creek Coalfield PROJECT Work Order 005 STATE Montana SHEET 3 OF 3 HOLE NO 77-101

NOTE:

SUITABILITY OF BEDROCK FOR RECONSTRUCTED PROFILES

SUITABLE- Can be used at or near the surface
LIMITED SUITABILITY- Should be placed in subsoil
UNSUITABLE- Should be buried below primary root zone

NOTE
Multiply feet by 0.3048 to obtain meters

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
RESOURCE & POTENTIAL RECLAMATION EVALUATION
CROMO/4 STUDY SITE
OTTER CREEK COALFIELD-MONTANA

GEOLOGIC LOG OF DH 77-101

GEOLOGY L. PARISH — SUBMITTED
DRAWN L.E. ALLSOP — RECOMMENDED
CHECKED — APPROVED

BILLINGS, MONTANA — APRIL 1978 — 1305-600-147

Stratigraphy

The Fort Union Formation of Paleocene Age underlies the entire area. It is divided into the Tullock, Lebo and Tongue River Members. The Tullock and Lebo Members are not discussed in this report as they are not exposed and were not encountered in drilling. Except for alluvium, only sediments in the lower part of the Tongue River Member are involved in the study area. The upper part of the Tongue River and younger rock have been stripped away by erosion. Brief descriptions of the Cenozoic sediments involved in the site follow:

Fort Union Formation (Paleocene)

Tongue River Member - pale olive to yellowish gray sandstone, siltstone, shale, carbonaceous shale and coal with thin lenticular calcareous or siliceous cemented concretions. Unweathered samples vary from light to dark gray in color. Poorly silicified, fragmented tree trunks and soft, calcareous shell fragments are common in zones. Sandstones, even though uncemented, tend to be resistant in outcrops. Shale and siltstone zones generally form slopes below sandstone ledges. Coal and carbonaceous beds are generally traceable over large areas. Conversely, correlation of clastic sediments over short distances is difficult due to variation in bedding thickness and lithologic changes. Tongue River sediments were deposited in a continental environment which included swamps conducive to the production of coalbeds. Thickness of this member varies from 1150 (350) to 1900 feet (579 m) in the Montana portion of the Powder River Basin.

One striking feature in the Tongue River Member is the resistant clinker zones that cap ridges or armor valley walls. The clinker, which is fused or baked rock, was produced by the burning of underlying coalbeds along their outcrops. In places where the heat was sufficiently intense, the clinker has been fused to a dark gray, lightweight rock similar in appearance to vesicular basalt. Near, the outer edge of thermal metamorphism, the rock is disoriented, baked and red to orange in color. Alteration of the overlying material is roughly proportional to the original thickness of coal that has burned. A coalbed 20 feet (6.1 m) thick will produce clinker zones 40 (12.2) to 60 feet (18.3 m) thick. The clinker is highly permeable and locally supplies water for springs and wells.

The most prominent clinker deposit near the study site was produced by burning of the Knoblock coalbed as shown on Plate 2. A second minor clinker produced by burning of the Odell coalbed, lies 150 (46) to 250 feet (76 m) above the Knoblock coal in the southwest part of the study site.

Only the Knoblock coalbed is of ecomomic significance at the Chromo/4 Study Site. The Knoblock thins and splits into several benches between the Otter Creek Study Site (EMRIA No. 1) and the Chromo/4 and Dam Creek Study Sites, respectively located about 6 (9.6) and 7 miles (11.3 km) southward. For locations, see Plate 1. At the Otter Creek Study Site, the Knoblock averages about 61 feet (18.6 m) thick. At the Otter Creek East Site, a distance of 3(4.8) to 4 miles (6.4 km) southward, the Knoblock splits into an upper and lower bench, 45 (13.7) and 17 feet (5.2 m) thick, respectively. At the Dam Creek Site, about 2 miles (3.2 km) south of the Otter Creek East Site, the upper bench of the Knoblock thins to about 24 feet (7.3 m) thick and geologic data in the Montana Bureau of Mines and Geology Bulletin 91 indicates that lower benches of the Knoblock are insignificant. At the Chromo/4 Site, about 1½ miles (2.5 km) southwest of the Otter Creek East Site, the Knoblock splits into five main benches. In descending order they are about 6 (1.8), 26 (7.9), 7 (2.1), 2 (.6) and 10 feet (3 m) thick.

Alluvium (Holocene)- deposits of clay, silt, sand and gravel that cover valley floors of Otter Creek and its tributaries. Gravels are generally composed of clinker or hard shale and sandstone fragments. The deposits are up to 20 feet (6.1) thick.

Structure

Sediments at the Chromo/4 Study Site and in the surrounding Otter Creek Coalfield are generally flat lying with minor folding evident on the surface and on subsurface contour maps constructed using drill hole information. Some of the structural irregularities may be of a depositional nature while others may be due to differential compaction of the underlying strata.

Small local faults exist in the area as indicated by slickensides encountered in the drill core. They are generally restricted to weak, plastic carbonaceous shales immediately above or below coalbeds. Displacement along the fractures could not be determined but probably does not exceed 5 feet (1.5 m). No faulting was observed during surface mapping.

Paleontology

Occasional poorly silicified tree fragments and pieces of unidentified calcareous shells were found on the surface of the area. However, nothing of significance was observed.

Engineering Geology

Engineering property tests were not conducted on bedrock samples from the Chromo/4 Study Site. However, physical properties of these sediments should be similar to the results obtained for Fort Union samples at the Otter Creek Study Site (EMRIA Report No. 1) by the U. S. Geological Survey. Shear strengths of the materials are low, especially in a saturated condition.

Slides could easily develop adjacent to high walls in surface mines, namely along beds of weak, plastic, carbonaceous shales, which are typically cut by inherent slickensides. Adequate drainage should be insured to relieve porewater pressures in the overburden as mine excavations progress.

Saturated alluvial deposits and uncemented siltstones and fine grain sandstones will readily erode and flow into excavations. This problem is occasionally encountered in drilling when the walls of holes continue to collapse and slough. Depth of excavation below the water table will be limited until these materials are unwatered.

Excavation slopes will vary considerably between mine sites and will depend upon exposure time, moisture conditions, material types and depth of cut. Detailed engineering studies of the overburden will be required at each location for use in determination of designed slopes.

Studies conducted at the Otter Creek Study Site indicate that disturbed overburden (spoil banks and piles) should have slopes not greater than 4 to 1 with berms of 50 (15) to 100 feet (30.1 m) in width designed on the slope surface.

Coal Resources

Coal Analyses

The proximate, ultimate, Btu and sulfur forms analyses were completed by Northern Testing Laboratories in Billings, Montana, on one composite sample (DH77-101 at depths 143.9-149.7, 154.5-180.8, 182.0-188.9 and 215.3-225.6 feet or 43.9-45.6, 47.1-55.1, 55.5-57.6 and 65.6-68.8 meters) from the study site. Test results are shown Table 2. Results indicate that the coal is of Subbituminous C rank with heat value of 8290 Btu as received. The ash and sulfur content as received is 3.66 and 0.32 percent, respectively.

Estimation of Coal Resources

The term "coal resources" is defined as the estimated quantity of coal that is currently or potentially economically mineable. Resource estimates have been prepared for the Chromo/4 Study Site using standard procedures and are presented on Table 3.

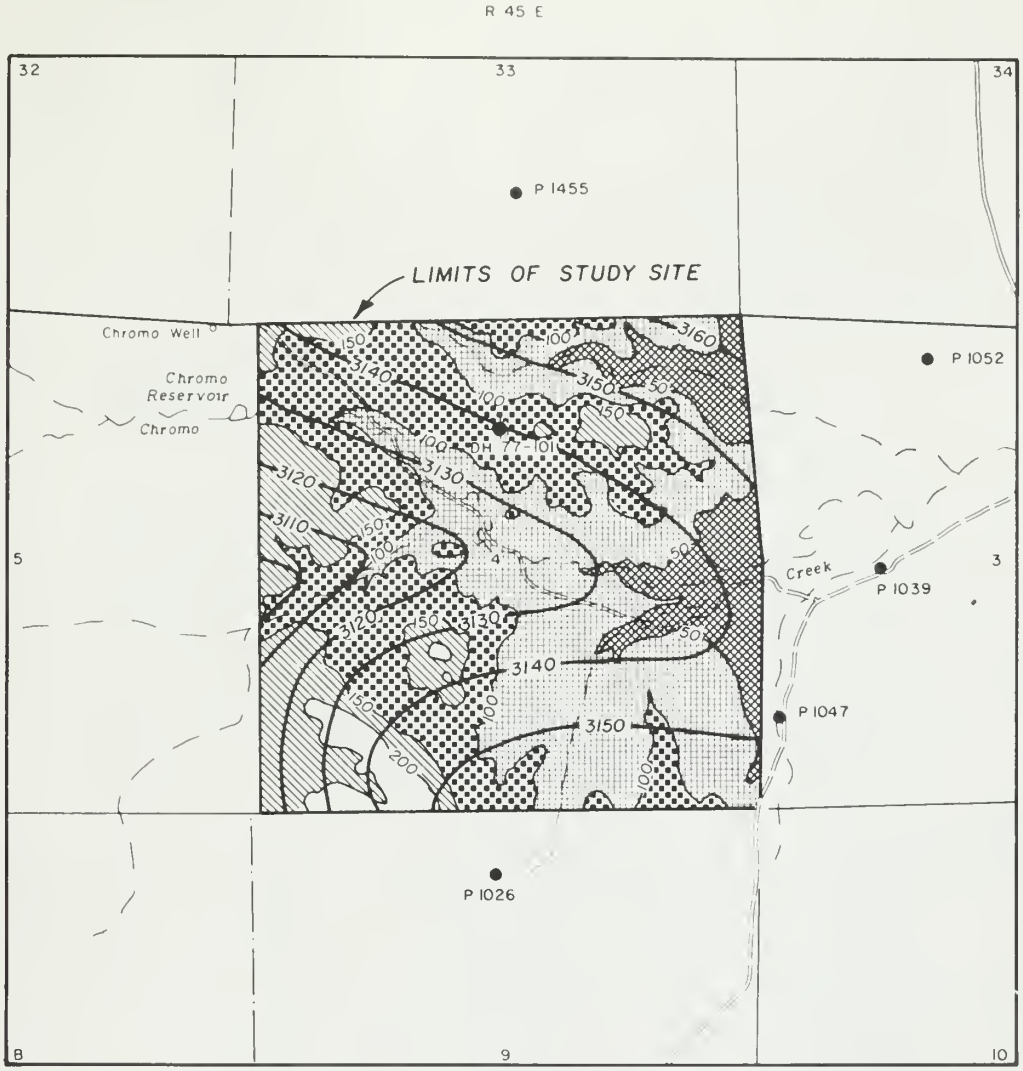
The quantities shown are categorized as demonstrated resources and are the sum of measured and indicated resources. They contain coal for which estimates of rank, quality and quantity are known and coal for which estimates have been at least partly computed using reasonable geologic projections.

Table 3 shows coal reserves for the Knoblock coalbed which at the Chromo/4 Study Site is divided into three main sets of beds - the upper, middle and lower coalbeds. Because of their closeness, the quantities for the Upper Knoblock and the Middle Knoblock have been combined. The quantity for the Lower Knoblock is shown separately.

Nearly all of the study site is covered with less than 200 feet (61 m) of overburden above the Upper Knoblock (Plate 4). Table 3 divides the coal reserves of the Upper and Middle Knoblock coalbeds into quantities covered by set ranges of overburden thicknesses.

Two thicknesses of interburden, one below the Upper Knoblock and one split in the Middle Knoblock are not included in the stripping ratios shown in Table 3. This is noted in the footnotes section.

The interburden between the Middle and Lower Knoblock coalbeds averages about 40 feet (12.2 m) at the study site and quantities and stripping ratios have been figured separately for it.



EXPLANATION

OVERBURDEN ABOVE UPPER KNOBLOCK COALBED

- 0 TO 50 Feet
- 50 TO 100 Feet
- 100 TO 150 Feet
- 150 TO 200 Feet
- OVER 200 Feet
- —3130— Structure contour on top of Upper Knoblock Coalbed
- —100— Contour showing depth to top of Upper Knoblock Coalbed
- OH 77-101 USBR Drill hole
- P 1455 Drill hole from USGS Miscellaneous Field Studies Map MF-817

1000 0 1000 2000 3000
SCALE OF FEET

NOTE
Multiply feet by 0.3048 to obtain meters

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

RESOURCE & POTENTIAL RECLAMATION EVALUATION

CHROMO/4 STUDY SITE
OTTER CREEK COALFIELD - MONTANA

OVERBURDEN THICKNESS MAP KNOBLOCK COALBED

GEOLOGY L. PARISH SUBMITTED
DRAWN L.E. ALLSOP RECOMMENDED
CHECKED APPROVED

BILLINGS, MONTANA APRIL 1978 1305-600-148

REVISED: APRIL 18, 1978

Report of: Coal Analysis

Date April 3, 1978
Job Number 61-114-1
Sheet 1 of 1

Report to: BUREAU OF RECLAMATION (1)
P O BOX 2553
BILLINGS MT 59103

Sample Identification:

On March 15, 1978, this coal sample was delivered to our laboratory with instructions to perform the following analyses.

TEST RESULTS:

Drill Hole : 77-101
Area : Otter Creek - Chromo 4
Depth, ft. : 143.9-149.7; 154.5-180.8; 182.0-188.9; 215.3-225.6
Coal Composite
Lab No. : 10472

Analysis	Proximate	Ultimate		Sulfur Forms	
% Moisture:		% Carbon:		% Pyritic Sulfur:	
As Received	31.90	As Received	48.47	As Received	0.02
Air Dry Loss	18.98	Air Dry	59.83	Air Dry	0.02
Oven Dry Loss	15.95	Oven Dry	71.18	Oven Dry	0.02
% Ash:		% Hydrogen**:		% Sulfate Sulfur:	
As Received	3.66	As Received	6.69	As Received	0.01
Air Dry	4.52	Air Dry	5.63	Air Dry	0.01
Oven Dry	5.38	Oven Dry	4.58	Oven Dry	0.01
% Volatile:		% Nitrogen:		% Organic Sulfur:	
As Received	26.43	As Received	0.85	As Received	0.29
Air Dry	32.63	Air Dry	1.05	Air Dry	0.36
Oven Dry	38.81	Oven Dry	1.25	Oven Dry	0.43
% Fixed Carbon:		% Oxygen**:			
As Received	38.01	As Received	40.01		
Air Dry	46.90	Air Dry	28.58		
Oven Dry	55.81	Oven Dry	17.15		
% Sulfur:					
As Received	0.32				
Air Dry	0.39				
Oven Dry	0.46				
BTU, per pound:					
As Received	8,290				
Air Dry	10,233				
Oven Dry	12,175				
BTU, per pound:					
Ash, moist free	12,867				

**Includes coal moisture content in accordance with ASTM D3176.

Note:
Multiply feet by 0.3048 to obtain meters
Multiply Btu/pound x 1.80 to obtain kilogram-calories /kilogram

RESOURCE AND POTENTIAL RECLAMATION EVALUATION
OF
CHROMO/4 STUDY SITE
OTTER CREEK COALFIELD
SECTION 4, T. 5 S., R. 45 E.

COAL RESERVES, OVERBURDEN AND INTERBURDEN VOLUMES AND RATIOS,
ACRES AND TONS PER ACRE

UPPER AND MIDDLE KNOBLOCK COALBEDS [1/]

Thickness of Overburden Ft.	Measured and Indicated Reserves Million Tons	Overburden Million Cubic Yards	Overburden Ratio [2/] Cubic Yards Per Ton	Acres	Tons Per Acre
0-50	4.11	3.10	0.75	64	64,219
50-100	15.42	29.04	1.88	240	64,250
100-150	13.17	41.34	3.14	205	64,244
150-200	5.98	26.26	4.39	93	64,301
200+	1.22	6.74	5.52	19	64,211
	Total 39.90	Total 106.48	Average 2.68 *	Total 621	Average 64,245

LOWER KNOBLOCK COALBED [3/]

Assumed Representative Thickness of Interburden Between Middle and Lower Knoblock Coalbeds	Measured and Indicated Reserves Million Tons	Interburden Between Middle and Lower Knoblock Coalbeds Million Cubic Yards	Interburden Ratio Cubic Yards Per Ton	Acres	Tons Per Acre
40	11.10	40.08	3.61	621	17,874.40

FOOTNOTES:

1/ Combined coal thickness of Upper and Middle Knoblock Coalbeds averages about 36.3 feet.

2/ Interburden within the Upper and Middle Knoblock Coalbeds (two splits) varies from 5 to 11 feet (upper split) and 1 to 6 feet (lower split). This interburden is not included in the stripping ratios shown.

3/ Thickness of Lower Knoblock Coalbed averages about 10.1 feet.

NOTES:

Thickness of coal, overburden and interburden based on data from U.S.B.R. drill hole DH77-101 and drill holes P1455, P1052, P1039, P1047 and P1026 as shown on sheets 1 and 2 of U.S.G.S. Miscellaneous Field Studies Map MF-817 and Plates 2 and 3 of this report.

*Average shown is a weighted average based on the number of acres per individual ratio.

English to Metric Conversions

Multiply	by	To Obtain
Feet	0.3048	Meter
Acre	0.4047	Hectare
Ton	0.9072	Tonne
Cubic Yard	0.7646	Cubic Meter

LAND CLASSIFICATION

Land classification is a systematic appraisal of lands for a specific purpose. In this classification, lands were grouped in classes 1, 2, 3 or 6 based on their physical and chemical properties that related to their use for plant media in reclaiming surface-mined land. Specifications are on Table 4.

Description of the Land

The principal natural land bodies consist of residual soils with some colluvial and alluvial soils of local origin. Within each soil type there is a range of physical and chemical properties. In this site colluvial soils are the most uniform and residual soils are the most diverse. The principal land condition represented by each soil group is described separately.

Alluvial Soils

The alluvial soils in this site are along the channel of small intermittent upland natural drains. Surface gradients range from 0 to 6 percent. The vegetative cover is largely mid and short grasses with scattered big sage and a few forbes.

Weakly developed loamy soil profiles are most common. This material is permeable, retains up to 2 inches (51 mm) of water per foot (.3 m), is well-drained, and is relatively stable. Precipitation enters and moves through this soil readily; therefore, surface runoff and erosion are minimal. The vertical water movement has usually leached the soluble salts below 24 inches (.6 m). Free carbonates occur just below the surface layer and the subhorizons are often saline and may be gypsiferous.

These soils are well suited for use as plant media. However, they occupy less than 1 percent of the study site.

Colluvial Soils

The colluvial soils are on footslopes of small natural drains and fans in the upland. They have developed under a mid and short grass plant association that has a moderate amount of big sage and forbes. Slope gradients range from 4 percent with many short steep slopes (35%) along natural drains.

Loamy and fine loamy soil profiles with moderate development are most common. The physical and chemical properties of the surface few inches are similar to the alluvial soils. The lower horizons and substrata have retained many of the physical and chemical properties of the parent material. This material is usually fine textured, slowly permeable and saline. It retains about 2 inches (51 mm) of available water per foot (.3 m). Surface runoff and erosion are in part slope dependent and range from low to moderate.

The upper 12 (.3) to 18 inches (.46 m) of soil are well suited for plant media. It may be placed at or near the surface of reconstructed profiles. Lower horizons are best suited for use immediately below the surface layer or deeper.

Residual Soils

In this site the residual soils are on narrow ridges, knobs and steep and eroded slopes. The vegetative cover is variable and reflects the interaction of slowly permeable soils, slope gradient and the resultant erosion. Mid and short grasses are most common, but the number of forbes and salt-tolerant sedges and shrubs is moderate. Slope gradients range from 4 to over 35 percent. The rate of erosion is usually high.

Soil profile development is minimal and the physical and chemical properties below the surface 3 (.08) to 5 inches (.13 m) are similar to the underlying Fort Union Formation. This material is usually soft silty and clayey shales. This subsurface material is fine-textured, slowly permeable, commonly saline and sodic. Slick spots occur on smooth gentle slopes.

A composite of the surface 6 inches (.15 m), the approximate minimum stripping depth, will be fair-to-good for use as plant media. Residual soils represent 95 percent of the site. Raw shale exposures and rock outcrops are included in this soil type.

Description of Classes

Class 1 land has no major soil and or topographic limitations. Topographically, this land is well-suited for stripping and stockpiling good quality overburden for use as plant media. The physical and chemical properties of this material make it suitable for use at or near the surface of reconstructed profiles. Land in this class is usually a good source of topdressing material. Excess material may be used in tracts with insufficient good-quality plant media.

Class 2 land has few soil and topographic limitations. Topographically this land can be stripped and stockpiled without special practices. The suitability of this material for use as plant media is reduced because of texture, permeability, salinity or quantity. Class 2 land has sufficient material for reclamation, but is only a fair-to-poor source of borrow material.

Class 3 land is limited by topography and soils. Special measures such as selective stripping and borrowing topdressing material for localized tracts will be required. Most Class 3 land will have sufficient suitable overburden for reclamation. However, the reclamation potential will be lower because of quantity, texture, permeability, salinity or sodicity. A high level of management will be required for optimum reclamation through revegetation.

Class 6 land does not have sufficient suitable overburden for reclamation. Material must be borrowed or the available material modified for optimum results. The topography and land conditions also limit stripping. Steep eroded slopes, bluff-forming sandstone and rock outcrops are common. However, selective stripping of the best material will reduce the amount of borrow required.

LAND CLASSIFICATION SPECIFICATIONS SURFACE MINE RECLAMATION
Suitability of Overburden for Revegetation of Surface-Mined Areas
BLM/BR Cooperative Program EMRIA
Colowyo Study Site

Table 4
United States
Dept. of the Interior
Bureau of Reclamation
July 1977

Overburden Characteristics	Symbols Basic Subclass	Inform. & Defic.	Class 1	Class 2	Class 3
SOILS AND/OR BEDROCK	s				
Textures			Sandy loams to clay loams.	Sandy loam to silty clay loam.	Loamy sand to clay.
Coarse		v		Sandy loams sufficiently coarse to slightly reduce productivity, moisture retention and may increase erosiveness slightly.	Loamy sand in sufficient quantity to moderately reduce productivity and moisture retention, and may increase erosiveness moderately.
Fine		h		Profile should have sufficient material for top dressing; clayey type materials that are moderately permeable should be placed below .15 m in the reconstructed profile.	Profile should have sufficant material for top dressing; placement of clay in reconstructed profile; permeable .25 m plus; slowly permeable .75 m plus.
Depth		d	1 m of overburden that is suitable for plant media.	.5 m of overburden that is suitable for plant media.	.25 m of overburden that is suitable for plant media.
Sodicity		a	SAR not to exceed 9.0 in clay textured material but may be 20.0 in loam sand. Values may be higher if compensated by adequate gypsum.		
Salinity (m^s/cm)		s	Overburden with characteristics (chemical and physical) capable of producing an expected electrical conductivity at equilibrium with the natural precipitation must be readily available as follows:		
			Less than 4 m^s/cm	Less than 8 m^s/cm except the surface .25 m must be 4 m^s/cm	Less than 12 except the surface .25 m must be 4 m^s/cm
Available Water Holding Capacity		q	38 mm/.3m foot of overhurden	.25 mm/.3m of overburden	.19 mm/.3m of overburden
Hydraulic Conductivity		p	Adaquate to provide a well drained and aerated root zone and an infiltration rate adequate to prevent serious erosion.	Slightly restrictad; movement of drainage water and aeration in the lower root zone will be reduced. Infiltration rate may be reduced and erosion hazard increase slightly.	Restricted in the lower root zone and internal drainage may limit choice of plant species. Restricted infilitration may create serious but controllable erosion hazard.
Indurated Sandstone Stones and cobble		x	Permisaible stone in overburden that may be stockpiled and reuaed as surface soil 0 to .25 m 5%.	Permissible stone in overburden that may be stockpiled and reused as surface soil 0 to .25 m 10%.	Permiasible stone in overburden that may be stockpiled and reused as surface soil 0 to .25 m 20%.
Weatherability 1/			Will break down readily upon exposure to the weather.	May require short period to break down upon exposure.	May require extended period to break down.
Erodibility		e	Slight.	Moderate, controllable with average management.	Severe but controllabla with above average management and selective placement of overburden.
TOPOGRAPHY 2/	t				
Slope		g	Permisaible surface gradient g - 0 to 12% with amooth slopes.	Permissible surface gradient g - 0 - 20%.	Permissible surface gradient g - 0 - 35%.
Indurated Sandstone Massive and lenticular		r	None.	1 to 5% of area.	5 to 20% of area.
Cover		c	Not applicable.		
DRAINAGE	d		(Present drainage conditiona, surface and subsurface) are not a factor in this classification because of the anticipated land disturbance during mining. All soil properties evaluated to classify the land were also considered in evaluating material that may be placed in the subsurface drainage zone, but this evaluation did not affect the land classes.		
Class 6			Areas delineated in this class generally lack suitable material for stripping and stockpiling for surface use. One or a combination of the following deficiencies may result in the use of this class: (1) insufficient surface soil and bedrock of suitable quality at or near the surface; (2) topography which prevents general stripping and stockpiling; (3) rocklands with large amounts of massive indurated sandstone; (4) toxic overburden (soil and bedrock) on or near the surface. Reclamation of these lands will require material from outside the delineated area, from deep geologic strata, or special treatment of available material.		

1/ Applicable only to unweathered bedrock material.
2/ Not applicable to unweathered bedrock material.

Methods and Procedures

The chemical and physical properties of soil profiles were evaluated in typical land areas and the land classes were delineated on photographs. Most profiles were sampled for testing in the soil laboratory. After the laboratory tests were completed, the land classes were finalized on reproducible drawings.

Standard laboratory procedures of pH, conductivity (salts), water movement, and soil stability were performed on all samples. Trace elements and heavy metals were determined on the bedrock cores.

Typical profile descriptions are recorded on Tables 6 and 8. Erosion conditions are shown on Tables 5 and 7. Tables 5 through 8 are in the Appendix.

Results of Classification

Class 1 land occurs on 15 percent of the study site. This loamy textured material is of good quality and will be easily stripped and stockpiled.

Class 2 land makes up only 22 percent of this site. The major soil deficiencies are salinity and permeability. Sodium and rock are the other deficiencies.

Class 3 land occurs on 24 percent of the area. Soil deficiencies are sodicity, salinity and permeability. Some slick spots and rock and shale outcrops are included in this class. Some borrow will be required, but resurfacing material is adequate in most tracts.

Class 6 land represents 39 percent of the site. Small inclusions of good soil occur, but it is doubtful if they merit selective stripping.

The location and areal distribution of the land classes are shown on Plate 5. This drawing also shows the soil and topographic deficiencies.

Results of the screenable tests in the soil laboratory are recorded on Table 9 in the Appendix.

Plate 6 shows the location and the approximate depth of the topsoiling material. Plate 7 shows the depth, quantity and quality of material suitable for subsurface placement.

Soil Inventory

The Powder River Area soil survey data is shown on Plate 8. The slope limitations and map symbols used by the Soil Conservation Service are shown. The acreage and percent of the study site occupied by each series is tabulated on this Plate.

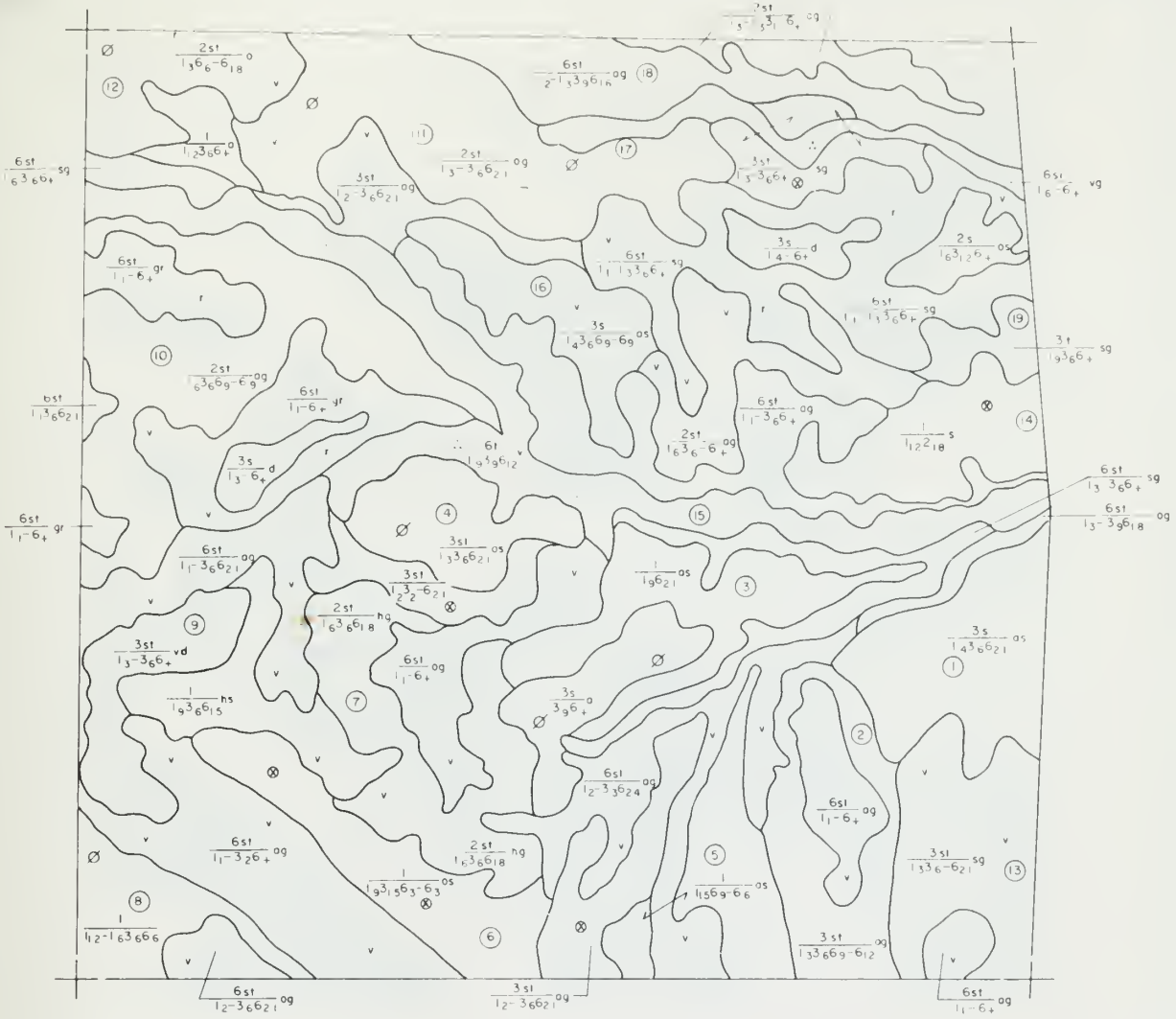
Reclamation Potential

The conditions in this site are adequate for reclaiming this land if the site is surface mined. The soil and topographic conditions are best suited for returning the site to range. Adding borrow material to class 6s and 6st tracts is necessary for satisfactory reclamation. However, profile enhancement and increased range production under post-mining conditions are possible on a limited amount of land.

To achieve maximum or optimum productivity levels under post-mining conditions, the following measures should be considered and used where applicable: (1) Add borrow material to some class 3s and 3st tracts, (2) Class 6 land must receive additional topdressing material and (3) strip and stockpile all suitable overburden for topdressing reshaped spoils. The quantity of this material would be determined by the post-mining goals of optimum or maximum productivity. Other measures that should be considered and used where applicable are (1) slope reduction and (2) reduce the number of moderately steep south and southwest facing slopes.

Regardless of the goal selected, the mining plan should also provide for the use of current approved land preparation and planting methods. Plant species, that are compatible with the land conditions, should be selected from an approved list.

The 40 acre tract now producing small grains can be returned to this capability level. There may be a few additional small tracts (10 to 40) acres that could be made suitable for small grain production in this site.



EXPLANATION

SOIL PROFILE NOTES

PROFILE REPRESENTS 5' DEPTH

(3) SOIL PROFILE NUMBER

C L. — 2 8 / 8 4 - 8 0 — 2 8 EC mmhos/cm Sat Ext; 8 4 pH 1 5 Soil-Water Suspension; 8 0 pH Soil-$CaCl_2$ Suspension

Lt C — 6 5 / 2 4 — 6 5 Hydraulic Conductivity - in /hr (Disturbed Sample); 24 Settling Volume

Gr

SOIL PROFILE SYMBOLS

Cb	Cobble
Gr	Gravel
S	Sand
LS	Loamy Sand
SL	Sandy Loam
L	Loam
SiL	Silt Loam
SCL	Sandy Clay Loam
CL	Clay Loam
SiCL	Silty Clay Loam
SC	Sandy Clay
C	Clay
SiC	Silty Clay
Sh	Shale
Ss	Sandstone
F	Fine
Lt	Light
M	Medium
H	Heavy

INFORMATIVE SYMBOLS

OVERBURDEN DEFICIENCIES (for plant media)

- a Salinity
- s Sodicity
- h Clay (very fine texture)
- v Coarse (very sandy texture)
- p Restricted permeability
- q Available moisture capacity
- d Depth of suitable overburden
- x Stoniness

TOPOGRAPHIC DEFICIENCIES

- g Slope (including gradient and complexity)
- r Massive lenticular sandstone and/or Glacial erratics
- c Cover

CONVENTIONAL AND SPECIAL MAP SYMBOLS

LAND FEATURES

- Blowout
- Clay spot
- Gravelly spot
- Gumbo, slick or scaby spot (sodic)
- Dumps and similar nonsoil areas
- Rock outcrop (includes shale and sandstone)
- Baked rock - clinker (local name scoria)
- Slide or slip (tips point upslope)
- Stony spot, very stony spot
- Greasewood
- Soil Profile (check)

WATER FEATURES

- Marsh or swamp
- Spring
- Well, artesian
- Well, irrigation
- Wet spot

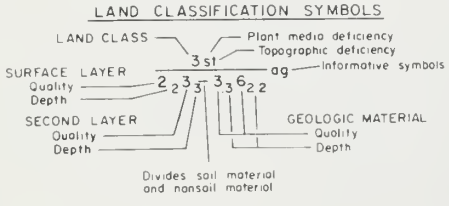
PITS

- Gravel
- Mine

DAMS

- Medium or small

LAND CLASSIFICATION SYMBOLS



Section 4 , T 5 S - R 45 E

250 0 250 500

SCALE OF METERS

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

RESOURCE & POTENTIAL RECLAMATION EVALUATION

CHROMO/4 SITE
OTTER CREEK COALFIELD - MONTANA

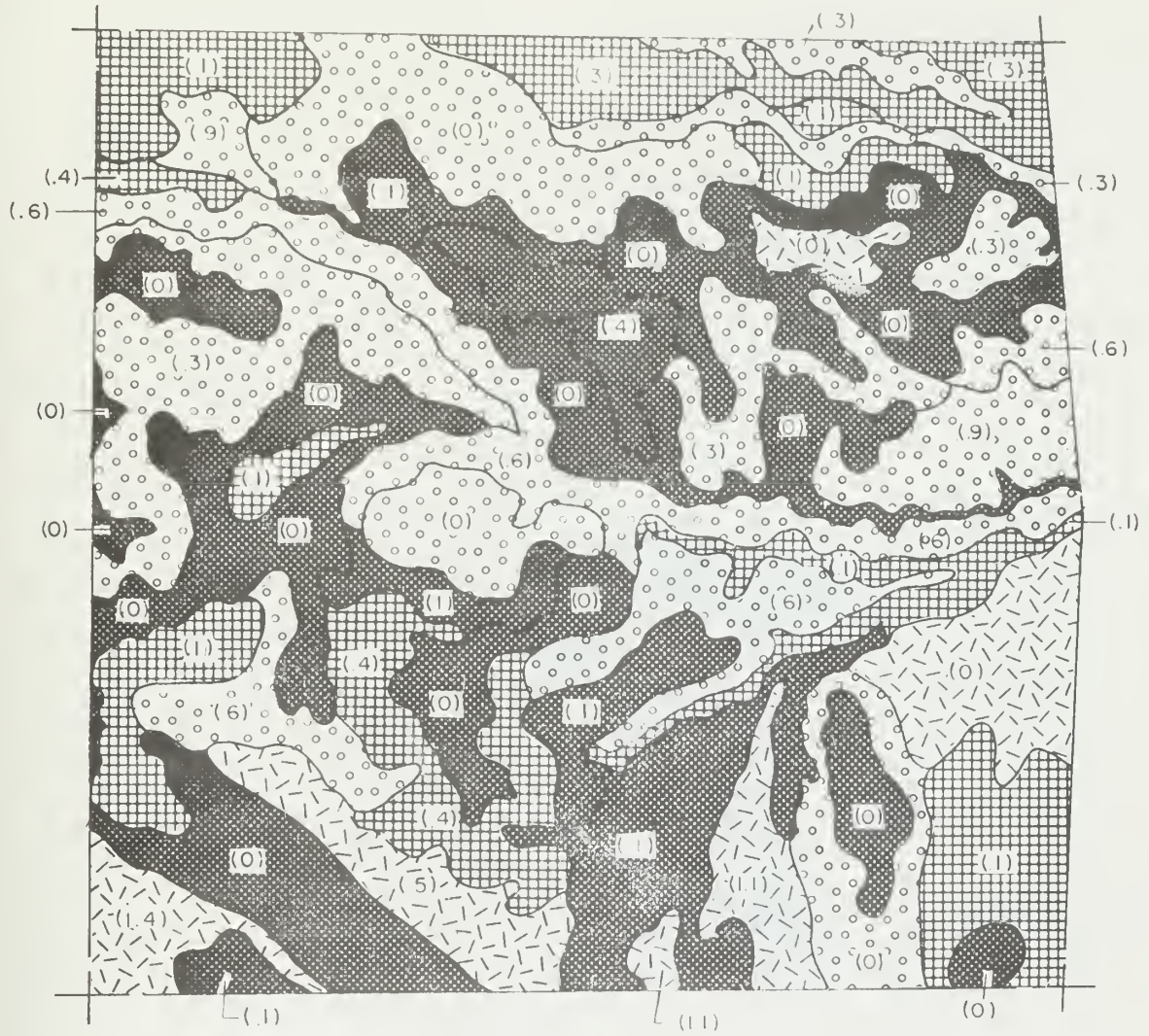
SEMI-DETAILED LAND CLASSIFICATION

LANDS H B WARD — SUBMITTED

DRAWN L E ALLSOP — RECOMMENDED

CHECKED — APPROVED

BILLINGS, MONTANA — MARCH 1978 — 1305-600-149



EXPLANATION

DEPTH OF TOPSOILING MATERIAL

MATERIAL FOR USE ON OR NEAR THE SURFACE

		ACRES
	0 - 0.1	210.3
	0.1 - 0.2	117.6
	0.2 - 0.3	224.6
	0.3 - 0.4	68.5

TOTAL ADDITIONAL SUITABLE MATERIAL

(.6) 1/

1/ Material over the amount indicated by the zip-a tone symbols
Best use below 0.1 meters

Section 4, T. 5 S. - R. 45 E.

250 0 250 500 750

SCALE OF METERS

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

RESOURCE & POTENTIAL RECLAMATION EVALUATION

CHROMO/4 SITE
OTTER CREEK COAL FIELD - MONTANA
TOPSOILING MATERIAL

LANDS - H. B. WARD — SUBMITTED
DRAWN - L.E. ALLSOP — RECOMMENDED
CHECKED — APPROVED

BILLINGS MONTANA — MARCH, 1978 — 1305-600-150

EXPLANATION

MATERIAL SUITABLE FOR SUBSURFACE PLACEMENT
QUALITY OF MATERIAL

- Good
- Fair
- Poor
- NS (Not Suitable)
- Material to 3 meters is suitable for use at or near the surface.

DEPTH TO MATERIAL FOR SUBSURFACE PLACEMENT 6' 1/

NOTE

Usable material for subsurface, as used in this report includes that portion of the overburden (soil mantle and bedrock) that should be placed 1/ below the primary plant root zone in reconstructed profiles. It contains no known toxic elements but may be clayey, sandy or highly saline. However, the soluble salts will leach from material subjected to downward movement of natural precipitation.

1/ Unless modified by leaching, mixing or other measures.

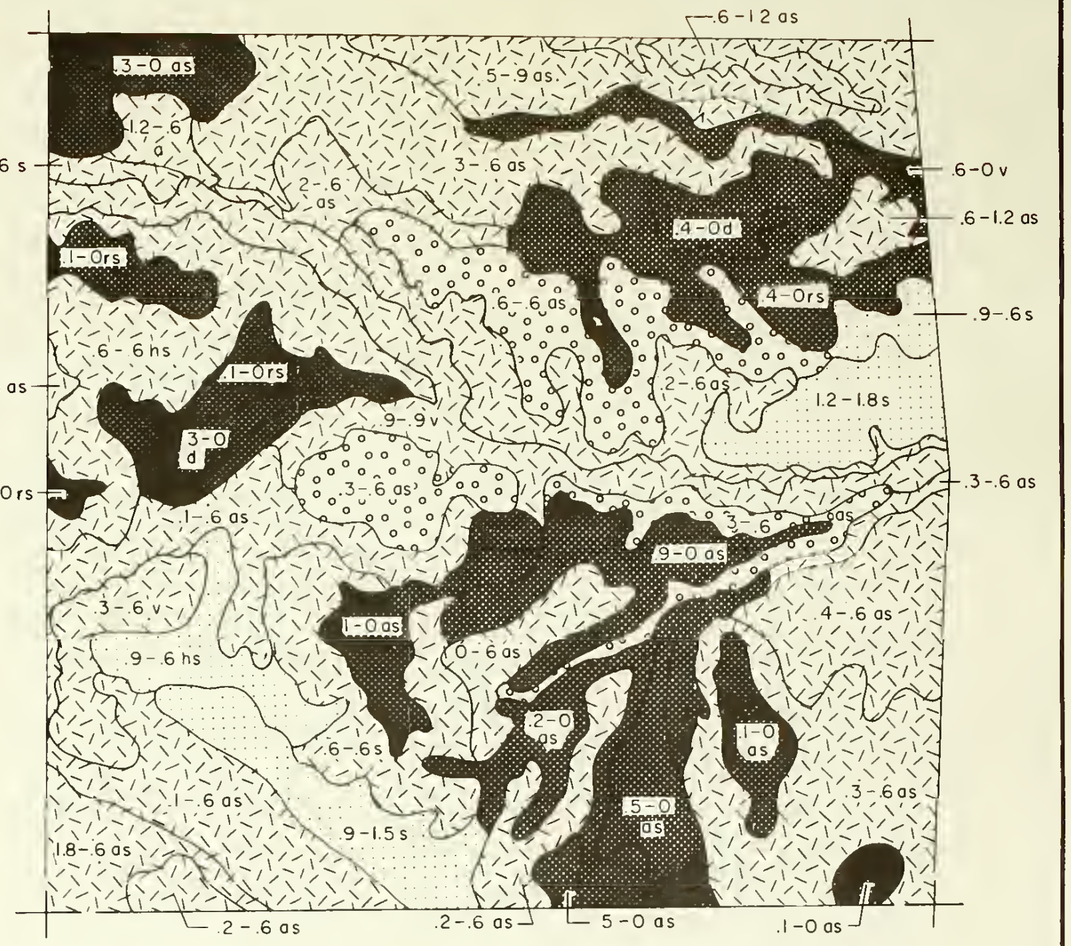
INFORMATIVE SYMBOLS

OVERBURDEN DEFICIENCIES
(for plant media)

- a Salinity
- s Sodicity
- h Clay (very fine texture)
- v Coarse (very sandy texture)
- p Restricted permeability
- q Available moisture capacity
- d Depth of suitable overburden
- x Stoniness

TOPOGRAPHIC DEFICIENCIES

- g Slope (including gradient and complexity)
- r Massive lenticular sandstone and/or Glacial erratics.
- c Cover

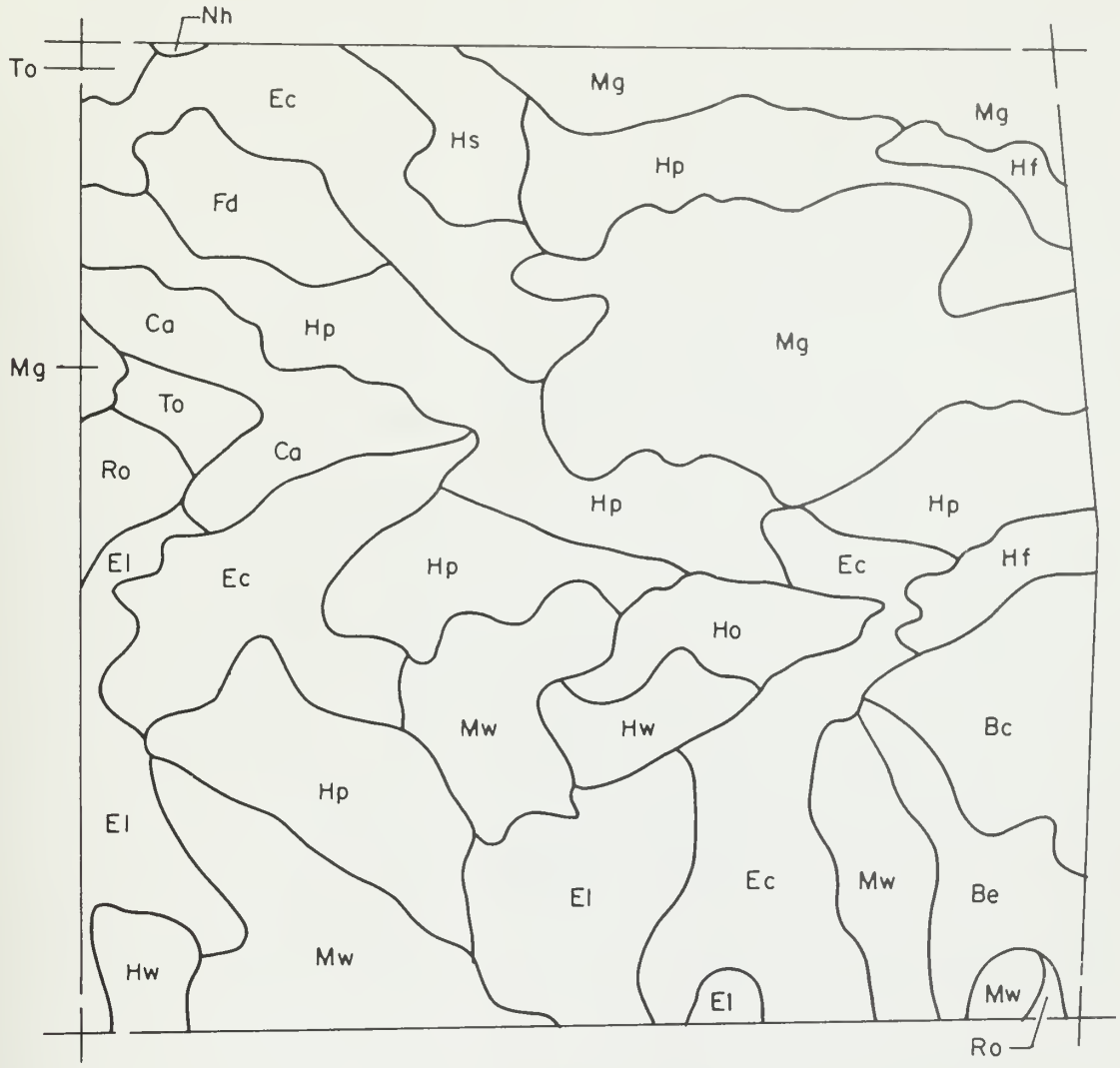


Section 4, T. 5 S.- R. 45 E.

250 0 250 500 750
SCALE OF METERS

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
RESOURCE & POTENTIAL RECLAMATION EVALUATION
CHROMO/4 SITE
OTTER CREEK COAL FIELD - MONTANA
SUBSURFACE MATERIAL

LANDS H B WARD SUBMITTED
DRAWN L E ALLSOP RECOMMENDED
CHECKED APPROVED
BILLINGS, MONTANA MARCH, 1978 1305-600-151



	SOIL SERIES	SLOPE – %
Bc	Bew silty clay	0 – 2
Be	Bew silty clay	2 – 4
Ca	Cabba association	15 – 50
Ec	Elso silt loam	8 – 15
El	Elso silt loam	15 – 45
Fd	Farland silt laam	2 – 4
Hf	Haversan soils, channeled	
Ho	Hesper silty clay laam	2 – 4
Hp	Hesper silty clay loam	4 – 8
Hs	Hopley and Relan laams	4 – 8
Hw	Hydro-Arvada complex	2 – 8
Mg	Midway-Elso assaciation	8 – 35
Mw	Midway and Elsa rocky sails	35 – 75
Nh	Nihill-Elso assaciation	8 – 15
Ro	Remmit-Ocean Lake fine sandy loams	8 – 25
Ta	Thurlaw silty clay laam	4 – 8

Section 4, T. 5 S. – R. 45 E.

250 0 250 500 750

SCALE OF METERS

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

RESOURCE & POTENTIAL RECLAMATION EVALUATION

CHROMO/4 SITE
OTTER CREEK COAL FIELD-MONTANA
SOIL SURVEY MAP

LANDS H B WARD SUBMITTED
DRAWN L E ALLSOP RECOMMENDED
CHECKED APPROVED

BILLINGS, MONTANA APRIL, 1979 1305-600-152

APPENDIX

Form 7310–12
(May 1973)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

By | Date

Location (8)

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS

SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT *	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. 6 **(7)** 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER *	Accumulating in place 0 1 2 3	May show slight movement 4 5 6	Moderate movement is apparent, deposited against obstacles **(7)** 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK *	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 **(5)**	If present, fragments have a poorly developed distribution pattern caused by wind or water 6 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING *	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 5 **(6)**	Small rock and plant pedestals occurring in flow patterns 7 8 9	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS *	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits **(7)** 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 15
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 6	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 7 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes 0 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 **(6)**	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15
SITUATION	TOTAL				
			(41)		

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

Table 5

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

VEGETATION–SOIL DESCRIPTION

1. State	2. District	3. Planning Unit	4. Vegetation–Soil Unit	5. Soil Map Symbol	6. Surname	7. Date
Mont.	02	08	———— / ————	———	————	11 mo 78 yr

8. Area	9. County	10. Location	11. Photo No.	12. Writeup No.	13. File No	14. Parent Rock
78	P. River	Sec. 4, T. 5 S, R 45 E	————	———	———	Sandstone

15. Formation Name	16. Surface Conditions (percent)	17. Land Conditions	18. Landform
Fort Union	Stone — Rock —	Alkaline Mod. Saline Mod. Water table —	Colluvial

19. Slope (percent)	20. Aspect	21. Elevation	22. Present Erosion	23. Hydrologic Group
2-4% ☐ Single ☑ Complex	E	972 m	Slightly Type Sheet SSF 41 Class Mod	—

24. Precipitation (in)	25. Temperature	26. Frost-free	27. Drainage Class	28. Infiltration	29. Percolation	30. ERD	31. AWC
12-16" 1st . 2nd . 3rd . 4th	— Air — Soil	Days 100 > 28°	Mod.	Slow	Slow	.43 m	.05+ m per .3 m

32. HORIZON	33. THICKNESS m	34. COLOR DRY MOIST — MATRIX	34. COLOR DRY MOIST — MOTTLING	35. TEXTURE	36. STRUCTURE	37. CONSISTENCY DRY MOIST	38. CLAY FILMS	39. ROOTS	40. STONES % VOL	41. REACTION (pH)	42. BOUNDARY
A_2	0-.05	(D) 10YR 6/3 (M) " 4/3	—	SiL	m1pl/ m1gr	(D) so (M) vfr	—	2f	—	—	a
AB	.05-.10	(D) 10YR 4/2 (M) " 4/2		<CL	c1pl/ m1bk	(D) sh (M) fr	—	2f	—	e	g
B_{2t}	.10-.30	(D) 10YR 5/3 (M) " 4/2		>CL	c2pr/ c2bk	(D) h (M) fr	2n	2f	—	es	a
B_3	.30-.40	(D) 10YR 5/3 (M) " 4/3		CL	c2pr/ c2bk	(D) h (M) fr	—	2f	—	es	g
C ca	.40-.56	(D) 10YR 6/3 (M) " 5/3		CL	c1pr/ c1bk	(D) h (M) fr	—	1f	—	es	g
C_2	.56-1.1	(D) 10YR 6/4 (M) " 6/3		CL	Massive	(D) h (M) fr	—	—	—	es	g
C_3	1.1-1.5	(D) 10YR 6/4 (M) " 6/3		CL	"	(D) h (M) fr	—	—	—	es	
BR	Semi Consolidated stratified sandy shale & carboniferous materials										
	.40-.56 horizon contains lime nitings & or seams										
	.56-1.1 salt crystals										
	Texture of B_{2t} may vary from heavy CL to light clay depending on location & position. Up to 35% slick spots may be in area.										

(Instructions inside back cover)

(B) 1750'N., 450'E. of S 1/4 Sec.

Form 7310-9a (December 1970)

Table 6

Form 7310–12
(May 1973)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

By | Date 11/77

Location (A) 4, T.5 S. R.45 E

Treatment affecting the SSF

DETERMINATION OF EROSION CONDITION CLASS

SOIL SURFACE FACTORS (SSF)

SOIL MOVEMENT *	No visual evidence of movement 0 1 2 3	Some movement of soil particles 4 5	Moderate movement of soil is visible and recent. Slight terracing generally less than 1" in height. (6) 7 8	Occurs with each event. Soil and debris deposited against minor obstructions. 9 10 11	Subsoil exposed over much of area, may have embryonic dunes and wind scoured depressions 12 13 14
SURFACE LITTER *	Accumulating in place 0 1 2 3	May show slight movement 4 5 (6)	Moderate movement is apparent, deposited against obstacles 7 8	Extreme movement apparent, large and numerous deposits against obstacles 9 10 11	Very little remaining *(use care on low productive sites)* 12 13 14
SURFACE ROCK *	If present, the distribution of fragments show no movement caused by wind or water 0 1 2	If present, coarse fragments have a truncated appearance or spotty distribution caused by wind or water 3 4 5	If present, fragments have a poorly developed distribution pattern caused by wind or water (6) 7 8	If present, surface rock or fragments exhibit same movement and accumulation of smaller fragments behind obstacles 9 10 11	If present, surface rock or fragments are dissected by rills and gullies or are already washed away 12 13 14
PEDESTALLING *	No visual evidence of pedestalling 0 1 2 3	Slight pedestalling, in flow patterns 4 5 6	Small rock and plant pedestals occurring in flow patterns 7 8 (9)	Rocks and plants on pedestals generally evident, plant roots exposed 10 11	Most rocks and plants pedestalled and roots exposed 12 13 14
FLOW PATTERNS *	No visual evidence of flow patterns 0 1 2 3	Deposition of particles may be in evidence 4 5 6	Well defined, small, and few with intermittent deposits (7) 8 9	Flow patterns contain silt and sand deposits and alluvial fans 10 11 12	Flow patterns are numerous and readily noticeable. May have large barren fan deposits. 13 14 15
RILLS	No visual evidence of rills 0 1 2 3	Some rills in evidence at infrequent intervals over 10' 4 5 (6)	Rills ½" to 6" deep occur in exposed places at approximately 10' intervals 8 9	Rills ½" to 6" deep occur in exposed area at intervals of 5 to 10' 10 11 12	May be present at 3" to 6" deep at intervals less than 5' 13 14
GULLIES	May be present in stable condition. Vegetation on channel bed and side slopes 0 1 2 3	A few gullies in evidence which show little bed or slope erosion. Some vegetation is present on slopes. 4 5 (6)	Gullies are well developed with active erosion along less than 10% of their length. Some vegetation may be present. 7 8 9	Gullies are numerous and well developed with active erosion along 10 to 50% of their lengths or a few well developed gullies with active erosion along more than 50% of their length 10 11 12	Sharply incised gullies cover most of the area and over 50% are actively eroding 13 14 15

SITUATION	TOTAL				
		45			

Erosion Condition Classes: Stable 0–20; Slight 21–40; Moderate 41–60; Critical 61–80; Severe 81–100

(Instructions on reverse)

Table 7

Table 8

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

VEGETATION–SOIL DESCRIPTION

1. State Mont	2. District 02	3. Planning Unit 08	4. Vegetation–Soil Unit	5. Soil Map Symbol	6. Surname	7. Date 11 77 yr

8. Area 78	9. County P. River	10. Location Sec. 4, T. 5 S, R 45 E	11. Photo No	12. Writeup No	13. File No	14. Parent Rock Sandstone

15. Formation Name Fort Union	16. Surface Conditions (percent) Stone — Rock 20 %	17. Land Conditions Alkaline Non Saline Non Water table None	18. Landform Residual

19. Slope (percent) 15-35% + ☐ Single ☑ Complex	20. Aspect E	21. Elevation [illegible]	22. Present Erosion [illegible] Type Rill & Gully SSF 46 – Class Mod.	23. Hydrologic Group B

24. Precipitation (in) 12-16" 1st, 2nd, 3rd, 4th	25. Temperature — Air — Soil	26. Frost-free Days 100 > 28°	27. Drainage Class Well Drained	28. Infiltration Moderate	29. Percolation Moderate	30. ERD .41 m	31. AWC .05 m per .3 m

32. HORIZON	33. THICKNESS m	34. COLOR DRY MOIST: MATRIX	MOTTLING	35. TEXTURE	36. STRUCTURE	37. CONSISTENCY DRY MOIST	38. CLAY FILMS	39. ROOTS	40. STONES % VOL.	41. REACTION (pH)	42. BOUNDARY
A1	0-.13	(D) 10YR 5/2 (M) " 4/2	—	FSL	m1bk/ m1gr.	(D) so (M) vfr	—	3f	—	ve	c
AC	.13-.20	(D) 10YR 6/2 (M) " 5/2	—	L	m1bk/ m1gr	(D) so (M) vfr	—	2f	—	e	c
C	.20-.35	(D) 10YR 7/2 (M) " 4/2	—	L	Massive	(D) so (M) fr	—	1f	—	es	g
CR	.35+	Softly consolidated sandy shales or sandstone. Roots readily penetrate fractures. Effective rooting depth is averaging .7 meters. Erosion is moderate with protective vegetation, severe without surface protection. Pine trees grow along upper edge of area. Exposed sandstone & shales are approximately 60% of area.									

Instructions inside back cover)

(A) 1300'E., 570' [illegible]

Form 7310–9a (December 1970)

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT CHROMO/4 PROJECT

SOIL SCIENTIST LOCATION - SECTION 4 T. 55 R. 45E DATE 11/77

LAB NO.	PROFILE NO.	DEPTH METERS	TEXTURE FIELD	TEXTURE LAB	pH 1-5	pH $CaCl_2$	SET. VOL. ml	EC 1-5	EC SAT. EXT.	FRAG. HYD. COND. 8 hr in./hr	FRAG. HYD. COND. 24 hr in./hr	SODIUM ADSORPTION RATIO TSC me/l	SODIUM ADSORPTION RATIO Cat. Mg me/l	SODIUM ADSORPTION RATIO SAR	GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE SAND	PARTICLE SIZE PERCENTAGE SILT	PARTICLE SIZE PERCENTAGE CLAY	HCL	%
1	1	0-.45	>CL		8.7	7.4	26	1.6 0.20		0.14	0.12								+	
	2	.45-1.1	CL		8.3		36	11.0 2.00	10.8	0.24	0.24								H	
	3	1.1-1.5	CL		8.7	8.2	50	11.5 2.10	9.0	0.06	0.06	90.0	63.0	13.8	-4.8				H	
	4	1.5-2.1	CL		8.6	8.2	100	10.5 1.90	7.0	0.00	0.03								H	
	5	2.1-2.7	SCL		9.2	8.2	140	5.4 0.75	8.5	0.00	0.00								H	
	6	2.7-3.0	SCL		9.1	8.1	96	5.4 0.75	7.5	0.00	0.00								H	
2	7	0-.30	CL		8.6	7.6	23	1.2 0.16		1.72	1.60								+	
	8	.30-.61	>CL/C		9.3	8.0	36	2.2 0.28		0.06	0.05								H	
	9	.61-1.2	>CL		8.8	8.3	50	12.0 2.30	20.0	0.48	0.48								H	
	10	1.2-1.7	CL		9.0	8.5	42	11.5 2.10	27.0	0.24	0.24	272.0	97.0	34.9	-2.8				H	
	11	1.7-2.3	>CL		8.3		37	16.0 3.60	27.0	0.07	0.07								H	
	12	2.3-2.7	>CL		8.2		35	16.0 4.75	22.5	0.11	0.13								H	
	13	2.7-3.0	>CL		8.3		45	15.0 3.20	21.0	0.07	0.08								H	

DOUBLE LINE RECORDS THE CONTACT BETWEEN SOIL MANTLE AND BEDROCK

Table 9 Sheet 1 of 10

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT CHROMO/4 PROJECT

SOIL SCIENTIST [illegible] LOCATION - SECTION 4 T. 55 R. 45E DATE 11/77

LAB NO.	PROFILE NO.	DEPTH METERS	TEXTURE FIELD	TEXTURE LAB	pH 1-5	pH $CaCl_2$	SET. VOL. ml	EC 1-5	EC SAT. EXT.	FRAG. HYD. COND. 8 hr in./hr.	FRAG. HYD. COND. 24 hr in./hr.	SODIUM ABSORPTION RATIO TSC me/l	SODIUM ABSORPTION RATIO Cat Mg. me/l	SODIUM ABSORPTION RATIO SAR	GYP. REQ me/100g	PARTICLE SIZE PERCENTAGE SAND	PARTICLE SIZE PERCENTAGE SILT	PARTICLE SIZE PERCENTAGE CLAY	HCL	%
3	14	0-.30	<CL		7.6		23	1.0 0.13		2.00	1.84								-	
	15	.30-.91	CL		9.1	7.8	22	1.5 0.19		0.34	0.36								++	
	16	.91-1.5	L		9.6	8.2	50	3.0 0.38		0.03	0.02								+	
	17	1.5-2.1	FSL		9.5	8.2	44	4.1 0.55	7.0	0.06	0.04	70.0	18.8	16.5	-5.2				+	
	18	2.1-2.6	FSL		9.2	8.2	50	4.8 0.65	9.0	0.68	0.64								++	
	19	2.6-3.0	FSL		9.2	8.1	50	4.8 0.65	9.0	0.82	0.80								++	
4	20	0-.30	CL		8.4		24	1.0 0.13		2.64	2.32								-	
	21	.30-.91	CL		9.6	8.1	50	2.5 0.31		0.12	0.13	25.0	4.8	13.5	-3.2				#	
	22	.91-1.4	<CL		9.5	8.5	33	6.4 0.90	9.0	0.02	0.01	90.0	31.0	14.75	-.4				++	
	23	1.4-2.0	<CL		9.3	8.6	32	8.6 1.40	15.0	0.00	Tr								+	
	24	2.0-2.4	<CL		9.2	8.6	40	9.8 1.70	18.0	Tr	Tr								#	
	25	2.4-3.0	<CL		9.0	8.5	70	9.8 1.70	18.0	0.52	0.48								++	

Table 9 Sheet 2 of 10

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT CHROMO/A PROJECT

SOIL SCIENTIST LOCATION - SECTION 4 T. 5°S R. 4.5°E DATE 1/17

LAB NO.	PROFILE NO.	DEPTH METERS	TEXTURE FIELD	TEXTURE LAB	pH 1-5	pH $CaCl_2$	SET. VOL. ml	EC 1-5	EC SAT. EXT.	FRAG. HYD. COND. 8 hr in./hr	FRAG. HYD. COND. 24 hr in./hr	SODIUM ABSORPTION RATIO TSC me/l	SODIUM ABSORPTION RATIO Cat.Mg. me/l	SODIUM ABSORPTION RATIO SAR	GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE SAND	PARTICLE SIZE PERCENTAGE SILT	PARTICLE SIZE PERCENTAGE CLAY	HCL	%
5	26	0-.46	CL		8.0		23	1.0 0.13		1.88	1.72								+	
	27	.46-.76	CL		8.7	7.8	21	1.0 0.13		0.84	0.72								++	
	28	.76-1.5	>SL		9.4	8.0	29	1.6 0.20		1.52	1.44								++	
	29	1.5-2.1	CL		9.6	8.3	130	4.4 0.60	4.0	0.00	0.00	40.0	7.2	17.2	0				++	
	30	2.1-2.6	CL		9.4	8.3	90	5.5 0.75	9.0	0.00	0.00								++	
	31	2.6-3.0	CL		8.3		40	13.5 2.70	15.0	0.34	0.36								+	
6	32	0-.46	CL		8.3		22	1.2 0.16		1.12	1.10								++	
	33	.46-.91	CL		9.1	7.6	20	2.6 0.32		0.68	0.60								++	
	34	.91-1.4	>CL		8.5		29	9.0 1.5	12.0	0.36	0.32								++	
	35	1.4-1.8	CL		8.6	7.9	24	7.4 1.1	12.5	0.74	0.62								++	
	36	1.8-2.4	CL		8.7	8.0	27	6.8 1.0	14.0	1.08	0.88								++	
	37	2.4-2.9	SCL		9.5	8.2	130	5.4 0.75	9.0	Tr	0.02								+	

Table 9 Sheet 3 of 10

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT CHROMO/4 1 PROJECT

SOIL SCIENTIST [illegible] LOCATION - SECTION 4 T. 5S R. 45E DATE 11/77

LAB NO.	PROFILE NO.	DEPTH METERS	TEXTURE FIELD	TEXTURE LAB	pH 1-5	pH $CaCl_2$	SET. VOL. ml	EC 1-5	EC SAT. EXT.	FRAG. HYD. COND. 8 hr in./hr	FRAG. HYD. COND. 24 hr in./hr.	SODIUM ABSORPTION RATIO TSC me/l	SODIUM ABSORPTION RATIO Cat Mg me/l	SODIUM ABSORPTION RATIO SAR	GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE SAND	PARTICLE SIZE PERCENTAGE SILT	PARTICLE SIZE PERCENTAGE CLAY	HCL	%
7	38	0-.30	CL		8.5		19	0.90 0.12		1.40	1.16								+	
	39	.30-.76	CL		9.2	7.8	23	1.8 0.23		0.18	0.15								+	
	40	.76-1.4	CL		8.9	8.1	28	7.0 1.0	9.5	1.28	0.21								+	
	41	1.4-2.0	CL	>CL	8.9	8.1	24	7.2 1.1	12.2	0.00	0.00					34	28	38	+	
	42	2.0-2.6	CL		9.4	8.1	29	4.4 0.6	6.0	0.09	0.05								+	
	43	2.6-3.0	CL		9.7	8.0	95	2.8 0.34		0.00	0.00								+	
8																				
	44	0-.46	CL		7.7		24	0.9 0.12		1.28	1.04								+	
	45	.46-.91	CL		8.4		21	0.75 0.10		0.68	0.56								+	
	46	.91-1.2	SCL		8.7	7.6	20	0.75 0.10		1.48	1.20								+	
	47	1.2-1.5	SCL		9.1	7.9	24	1.40 0.18		0.46	0.42								+	
	48	1.5-2.1	FSL		9.3	7.9	24	1.40 0.18		3.04	2.72								+	
	49	2.1-2.6	SCL		9.6	7.8	54	1.60 0.22		1.00	0.92	16.0	2.4	12.5	-1.2				+	
	50	2.6-3.0	SCL		9.6	7.9	115	1.60 0.20		0.00	0.02								-	

Table 9 Sheet 4 of 10

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT CHROMO/4 PROJECT

SOIL SCIENTIST [illegible] LOCATION - SECTION 4 T. 5S R. 45E DATE 11/77

LAB NO.	PROFILE NO.	DEPTH METERS	TEXTURE FIELD	TEXTURE LAB	pH 1-5	pH $CaCl_2$	SET. VOL. ml	EC 1-5	EC SAT. EXT.	FRAG. HYD. COND. 8 hr in./hr	FRAG. HYD. COND. 24 hr in./hr.	SODIUM ABSORPTION RATIO TSC me/l	SODIUM ABSORPTION RATIO Cal.Mg. me/l	SODIUM ABSORPTION RATIO SAR	GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE SAND	PARTICLE SIZE PERCENTAGE SILT	PARTICLE SIZE PERCENTAGE CLAY	HCL	%
9	51	0-.30	FSL	SCL/SL	7.6		22	0.50		5.60	8.00					76	4	20	—	
	52	.30-.91	LFS		8.5		19	0.75 0.10		2.48	1.80								—	
10	53	0-.30	L		8.2		21	0.90 0.12		2.00	1.64								+/-	
	54	.30-.91	<CL		8.8	7.6	19	0.90 0.12		1.36	1.08								+/-	
	55	.91-1.5	>CL/C		8.8	7.9	27	5.2 0.70	7.0	0.00	0.00	70.0	39.6	6.84					+/-	
	56	1.5-2.1	SCL		9.6	8.0	120	3.00 0.38		0.00	0.00								+	
	57	2.1-2.7	SCL		9.5	7.9	140	3.00 0.32		0.00	Tr								+	
	58	2.7-3.0	SCL		9.4	7.8	120	3.20 0.40		0.00	0.00								+	
11																				
	59	0-.30	L		8.3		22	0.90 0.12		1.64	1.24								+	
	60	.30-.91	CL		8.9	7.6	22	1.20 0.16		0.62	0.52								++	
	61	.91-1.4	CL		9.5	8.1	75	4.80 0.65	5.0	0.00	0.00								++	
	62	1.4-2.0	CL		8.6	8.0	40	8.60 1.42	14.25	0.72	0.60	142.5	51.0	15.5	-3.6				++	
	63	2.0-2.6	CL		8.7	8.1	50	7.10 1.0	14.0	0.40	0.35								++	
	64	2.6-3.0	CL		8.5		35	10.50 1.90	16.0	0.33	0.28									

Table 9 Sheet 5 of 10

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT CHROMO/4 PROJECT

SOIL SCIENTIST LOCATION - SECTION 4 T. 5S R. 45E DATE 11/77

LAB NO.	PROFILE NO.	DEPTH METERS	TEXTURE FIELD	TEXTURE LAB	pH 1-5	pH $CaCl_2$	SET. VOL. ml	EC 1-5	EC SAT. EXT.	FRAG. HYD. COND. 8 hr in./hr	FRAG. HYD. COND. 24 hr in./hr.	SODIUM ABSORPTION RATIO TSC me/l	SODIUM ABSORPTION RATIO Cat.Mg. me/l	SODIUM ABSORPTION RATIO SAR	GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE SAND	PARTICLE SIZE PERCENTAGE SILT	PARTICLE SIZE PERCENTAGE CLAY	HCL	%
12	65	0-.30	FSL	SCL/SL	7.2		20	0.75 0.10		5.60	8.00+					68	12	20	-	
	66	.30-.76	CL/SCL	SCL	9.4	7.7	60	2.50 0.32		0.03	0.01					60	14	26	++	
	67	.76-1.1	SCL		9.7	8.1	330	3.60 0.46		0.00	0.00								++	
	68	1.1-1.7	SCL		9.7	8.3	260	4.60 0.62	3.0	0.00	0.00								+	
	69	1.7-2.3	SCL		9.6	8.2	160	6.00 0.95	4.25	0.00	0.00								-	
	70	2.3-2.7	SCL		9.4	8.0	140	5.60 0.77	4.5	0.00	0.00								-	
	71	2.7-3.0	SCL		9.5	8.0	140	5.20 0.70	4.5	0.00	0.00								--	
13	72	0-.46	>CL		8.5		23	1.60 0.20		0.72	2.88								+	
	73	.46-1.1	>CL		8.1		27	7.80 1.20	7.2	0.60	1.24								++	
	—	1.1-1.2	S	No Sample.																
	74	1.2-1.7	CL		8.4		41	9.00 1.50	10.0	0.20	0.30	100.0	42.0	12.6	-4.0				++	
	75	1.7-2.3	CL		8.5		70	11.00 2.00	14.0	0.05	0.07								++	
	76	2.3-2.7	CL		8.2		70	13.50 2.40	18.0	0.00	0.02								+	
	77	[illegible]	CL		8.2		70	13.50 240	18.0	0.00	0.02								-	

Table 9 Sheet 6 of 10

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT CHROMO/4 PROJECT

SOIL SCIENTIST LOCATION - SECTION 4 T. 5S R. 4-5E DATE 11/76

LAB NO.	PROFILE NO	DEPTH METERS	TEXTURE FIELD	TEXTURE LAB	pH 1-5	pH $CaCl_2$	SET. VOL. ml	EC 1-5	EC SAT. EXT.	FRAG. HYD. COND. 8 hr in./hr	FRAG. HYD. COND. 24 hr in./hr	SODIUM ABSORPTION RATIO TSC me/l	SODIUM ABSORPTION RATIO Cal.Mg. me/l	SODIUM ABSORPTION RATIO SAR	GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE SAND	PARTICLE SIZE PERCENTAGE SILT	PARTICLE SIZE PERCENTAGE CLAY	HCL	%
4	78	0-.46	CL		7.6		24	1.60 0.20		2.56	8.00+								+	
	79	.46-.61	CL		8.2		21	1.20 0.16		0.27	0.31								++	
	80	.61-1.2	CL		8.8	7.7	23	3.00 0.38		0.17	0.17								++	
	81	1.2-1.7	CL		8.7	7.9	22	5.60 0.77	6.25	0.16	0.17								++	
	82	1.7-2.1	CL		8.6	7.9	22	6.20 0.85	5.50	0.20	0.21								++	
	83	2.1-2.7	L		8.6	7.7	21	4.20 0.55	4.50	0.22	0.24								++	
	84	2.7-3.0	<CL		8.3		21	4.20 0.55	4.0	0.29	0.33									
15	85	0-.30	<FSL		8.5		18	1.00 0.12		8.00+	8.00+								+	
	86	.30-.91	FSL		8.4		18	1.00 0.12		2.76	6.68								++	
	87	.91-1.2	<SL		8.6	7.5	17	1.00 0.12		3.84	8.00+								++	30
	88	1.2-1.8	Gr.LS																+	

Table 9 Sheet 1 of 10

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT CHROMO/A PROJECT

SOIL SCIENTIST [illegible] LOCATION - SECTION 4 T. 55 R. 45E DATE 11/77

LAB NO.	PROFILE NO.	DEPTH METERS	TEXTURE FIELD	TEXTURE LAB	pH 1-5	pH $CaCl_2$	SET VOL. ml	EC 1-5	EC SAT. EXT.	FRAG. HYD. COND. 8 hr in./hr	FRAG. HYD. COND. 24 hr in./hr	SODIUM ABSORPTION RATIO TSC me/l	SODIUM ABSORPTION RATIO Cat Mg me/l	SODIUM ABSORPTION RATIO SAR	GYP REQ me/100g	PARTICLE SIZE PERCENTAGE SAND	PARTICLE SIZE PERCENTAGE SILT	PARTICLE SIZE PERCENTAGE CLAY	HCL	%
16	89	0-.46	FSL		8.1		21	1.00 0.12		8.00+	8.00+								+	
	90	.46-1.1	>4CL		9.4	7.9	45	3.40 0.44	2.1	0.05	0.01	21.0	4.0	12.1	-1.6				++	
	91	1.1-1.7	CL		8.8	8.3	34	11.00 2.00	15.0	0.74	2.24								++-	
	92	1.7-2.1	CL		8.7	8.5	32	15.00 3.20	16.0	0.72	1.84								++	
	93	2.1-2.7	CL		8.3		36	16.00 3.60	16.0	0.44	0.88								+	
	94	2.7-3.0	CL		8.5		41	13.50 2.40	14.0	0.50	0.80								++	
17	95	0-.30	<CL		8.6	7.5	24	1.80 0.20		2.08	8.00+								+	
	96	.30-.76	CL		9.1	8.1	70	6.40 0.90	7.0	0.00	0.00								+-	
	97	.76-1.2	CL		9.1	8.5	70	9.00 1.50	14.0	0.07	0.06	140.0	42.5	21.2	-2.0				++-	
	98	1.2-1.7	CL		8.9	8.4	64	14.0 2.80	17.5	0.00	0.02								++	
	99	1.7-2.1	CL		8.8	8.4	45	16.0 3.60	20.0	0.04	0.04								++	
	100	2.1-2.7	L		9.2	8.6	37	8.5 1.40	20.0	2.27	2.36								++-	
	101	2.7-3.0	CL		9.1	8.5	100	8.0 1.30	15.0	0.00	0.05								-++	

UNITED STATES - DEPARTMENT OF THE INTERIOR - BUREAU OF RECLAMATION - UPPER MISSOURI REGION

SOIL LABORATORY - MILES CITY, MONTANA

UNIT CHROMO/4 PROJECT

SOIL SCIENTIST LOCATION - SECTION 4 T. 5S R. 45E DATE 11/77

LAB NO.	PROFILE NO.	DEPTH METERS	TEXTURE FIELD	TEXTURE LAB	pH 1-5	pH $CaCl_2$	SET. VOL. ml	EC 1-5	EC SAT. EXT.	FRAG. HYD. COND. 8 hr in./hr	FRAG. HYD. COND. 24 hr in./hr	SODIUM ABSORPTION RATIO TSC me/l	SODIUM ABSORPTION RATIO Cat Mg me/l	SODIUM ABSORPTION RATIO SAR	GYP. REQ. me/100g	PARTICLE SIZE PERCENTAGE SAND	PARTICLE SIZE PERCENTAGE SILT	PARTICLE SIZE PERCENTAGE CLAY	HCL	% gr
18	102	0-.30	L		8.3		25	1.0 0.13		2.32	5.84								++	37
	103	.30-.61	L		8.5		22	0.75 0.10		1.08	3.20								++	54
	104	.61-1.1	CL		8.5		22	1.0 0.13		0.64	1.34								++	
	105	1.1-1.5	L		8.8	7.7	22	0.75 0.10		3.92	5.44								+	
19	260	0-.30	L		8.4		20	1.20 0.16		1.12	1.60								++	
	261	.30-.91	L		9.0	7.6	20	2.70 0.34		0.52	0.52								+-	
	262	.91-1.5	SL		8.6	8.1	19	7.80 1.20	16.0	1.64	3.20								++	

Table 9 Sheet 9 of 10

MS28-19
(3/76)

MISSOURI SOURIS PROJECTS OFFICE
SOIL AND WATER LABORATORY
BUREAU OF RECLAMATION
BISMARCK, NORTH DAKOTA

SOIL ANALYSIS DATA SHEET

Date Received March
Date Reported

AREA Otter Creek Coal Field (Chrome #4) INVESTIGATOR: SECTION TOWNSHIP RANGE

Laboratory Number	Sack Number	Boring Number	Depth in Feet	Text. Field	Frag 2 Hr. in./Hr	Hyd 6 Hr. in./Hr	Cond. 24 Hr. in./Hr	Sat. Vol. ml.	pH @ 2 1:5	Milligram Per Liter B	Cd	Cu	Fe	Hg	Mn	Pb	Se	Zn	E Ce @ 25°C	SAR	M.R. % 15 BAR	Particle Size Percentage VCo. 2-1 (mm)	Co. 1-.5 (mm)	Med. .5-.25 (mm)	F 25-10 (mm)	VF 10-.05 (mm)	Sand 2 .050 (mm)	Silt .050 .002 (mm)	Clay CO2 (mm)	Lab Text Class
11,722	1	77-101	0'-22'		★ 1/8	★ 2/3	★	63.	9.5	0.0	0.14	1.0	34	0.048	21.4	2.2		2.3	1.2	15.	16.9						43.6	20.8	35.6	CL
1	2		22'-35'		<0.01	0.04	0.04	27.	8.1	0.4	0.42	6.0	102	0.083	32	2.0		8.6	5.7	6.0	12.9						19.1	65.4	23.5	SiL
4	3		35'-47'		★ 1/2	★ 2/3	★	55.	9.9	0.0	0.02	0.2	58	0.034	6.2	1.0		2.2	2.2	2.6	11.6	0.4	1.0	1.3	27.9	34.9	65.5	17.3	7.2	VFSL
5	4		47'-64'		★ 1/2	★ 2/3	★	43.	9.0	0.2	0.13	3.8	192	0.085	30	1.6		7.4	3.8		15.4						6.8	67.2	26.0	SiL
6	5		64'-77'		★ 1/2	★ 1/2	★ 9/10	61.	9.5	0.1	0.06	1.8	170	0.078	11.2	2.0			2.2		14.3						35.8	38.3	26.0	L
7	6		77'-100'		★ 1/2	★ 2/3	★	50.	8.3	0.7	0.44	11.0	222	0.085	44	4.4			7.2	37.	24.3						1.7	48.2	49.6	SiC
8	7		100'-115'		★ 1/4	★ 1/4	★ 1/3	78.	9.4	0.3	0.20	9.4	206	0.099	36	2.0			2.3		31.1						0.4	55.8	43.8	SiC
9	8		115'-143'		★ 1/5	★ 1/5	★ 1/4	225.	9.6	0.0	0.18	7.8	150	0.095	20.8	3.2			1.3	24.	45.9						2.0	55.0	35.6	SiCL
10	9		143'-154'		★ 2/3	0.07	0.17	42.	5.8	0.16	0.16	8.2	308	0.054	56	6.2			8.1	12.	24.1						4.6	47.7	47.7	SiC
1	10		192'-215'		★ 2/3	★	★	45.	9.3	0.0	0.09	3.6	118	0.078	16.6	2.8			3.0		13.6						9.9	60.	2.5	SiL
11,732	11		225'-239'		★ 1/5	★ 1/5	★ 1/4	148.	9.7	0.0	0.14	8.4	46	0.201	2.0	8.0			0.87	8.1	24.6						23.7	46.4	29.9	CL

Table 9 Sheet 10 of 10

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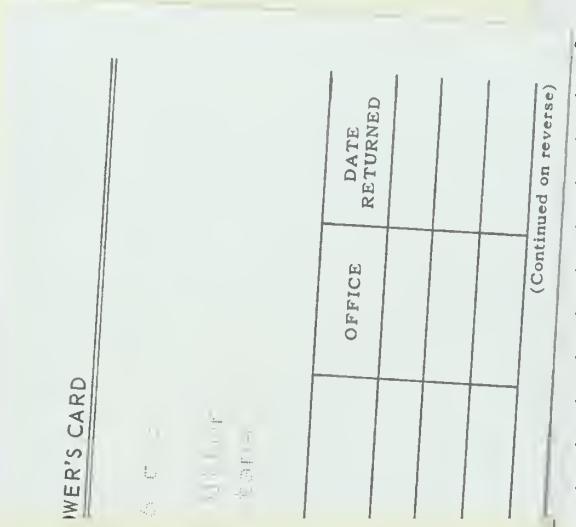

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